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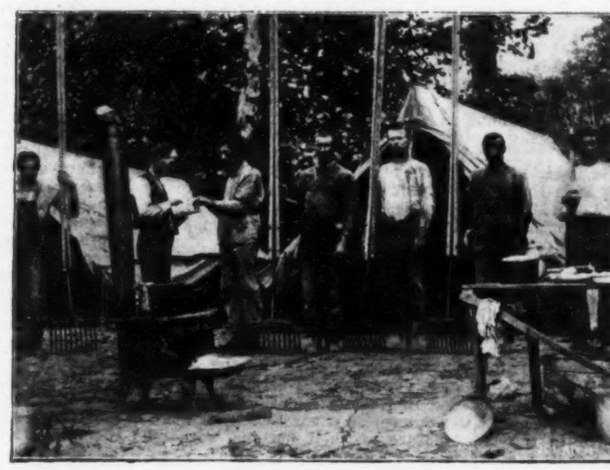
DIGGING SHELLS IN THE WHITE RIVER, ARK.



SHELL CAMPS IN ARKANSAS.

CUTTING THE BLANKS FROM THE SHELL.

SHAPING AND DRILLING ROOM.

AUTOMATIC DRILLERS.

CARDING AND SORTING ROOM.

THE MANUFACTURE OF FRESH-WATER PEARL BUTTONS.

FRESH-WATER PEARL-BUTTON INDUSTRY.*

The most important branch of the button industry of to-day in the United States is the manufacture of pearl buttons. It embraces buttons made from mother-of-pearl and from the shells of the Unios, which are so abundant in the Mississippi River. In value the production of these varieties of buttons in 1900 formed 48.4 per cent of the product reported for the entire button industry. The making of buttons from mother-of-pearl was introduced into the United States on a small scale about 1855. At that time, and for many years thereafter, the shells were brought from China, but now the markets of the world are supplied principally from South Australia and from the South Sea Islands. The technical name for buttons made of mother-of-pearl is "ocean pearl," while those made from the shell of the Unio are called "fresh-water pearl" buttons. The higher grades of pearl buttons are still manufactured from the ocean shell, and the production of these far outranked that of all other kinds, constituting 30.2 per cent of the total value of buttons manufactured in the United States.

In 1890 there was not a single fresh-water pearl button made in the United States. In 1900 the making of these buttons constituted the second most important branch of the button industry. In Europe shells of the mussels found in rivers have been utilized for button making for the last fifty years. To Mr. J. F. Boepple, of Muscatine, Iowa, belongs the credit of having started the industry in the United States, and now it is the source of income for thousands of persons. In 1891 Mr. Boepple, who is a native of Hamburg, Germany, where he learned the trade of making pearl buttons, formed a partnership for the manufacture of buttons from the Unio, or "niggerhead" shells, as they are called locally, which were banked up for miles along the river in front of Muscatine. After experimenting for some time this concern found the business unprofitable and it was dissolved. Nothing daunted, Mr. Boepple continued making the buttons, on a small scale, at his home. He finally organized a company which, by the process of manufacture and machinery utilized in Austria and Germany, succeeded in making the enterprise a success. The tools needed in the manufacture of shell buttons were of the simplest character, consisting, for the most part, of turning lathes worked by steam or foot power; consequently it was not long before the Mississippi River was lined with button factories all the way from Red Wing, Minn., to Louisiana, Mo. Muscatine, Iowa, became the center of this new industry. A few years ago there were more than 40 factories in that city for the cutting of blanks and for the making of buttons, but the tendency toward concentration has made itself felt, as has also the need of improved machinery and large capital to withstand the tremendous competition, and all along the river the smaller concerns are being eliminated. The difference in price between the ocean shells and the Unios has been an important factor in the development of the fresh-water button industry. A few years ago the mussel shells were delivered at the factories at about 50 to 60 cents per 100 pounds, while at the same time ocean shells were worth from $30 to $60 for the same quantity. In February, 1898, prices went up to $18 to $20 per ton for "niggerheads," but in July of the same year they were cheaper than ever before or since, selling at 30 cents per 100 pounds. The cheapest grade of ocean shells are the Panama, which sell at 10½ cents per pound.

The improvements in machinery in recent years have been so rapid that some manufacturers have exchanged their machines three times in three years, each time practically re-equipping the entire plants.

The following is a short résumé of the mode of making pearl buttons: After the mussels have been cooked and the meat removed, the shells are taken to the factories and stored in sheds. They are then sorted into three different sizes and soaked in barrels of water from three to six days to render them less brittle. They must be used while wet, otherwise they crumble under the saw. The next step is the cutting or sawing of the rough blanks. The shells are usually held with pliers while being cut, but some sawers hold them in their hands. The saws are hollow, cylindrical pieces of steel, 2 inches wide, and with a diameter corresponding to the size of the button. At one end these cylinders are provided with fine teeth; they are adjusted to lathes in which they revolve. As the sawyer holds the shell against the saw, the blanks are cut out and passed back into the saw and saw holder and drop into a receiver. The next step is the dressing or grinding of the back of the blank to remove the skin and make an even surface. To accomplish this, each blank has to be held with the finger against a revolving emery wheel. Then comes the turning, by which the front of the button is given its form, including the central depression. When the holes are drilled the button is complete, with the exception of the polishing process, which brings out the natural luster which was lost in the grinding. It is this luster which gives the buttons their chief value. The polishing is effected by placing the buttons in bulk in large wooden tumblers or kegs, in which they are subjected to the action of a chemical fluid as the tumblers revolve. By mutual contact, combined with the effect of the fluid, the buttons become highly lustrous. Then they are washed, dried, and sorted into sizes and grades of quality. After being sewed on cards and packed in pasteboard boxes, the buttons are ready for the market.

The majority of the factories in the West do not finish the buttons, but merely cut the blanks. These are then sent to the factories in the East, which are supplied with improved machinery for the finishing of the buttons. Some of these Eastern factories formerly made buttons out of imported mother-of-pearl shells, but now their principal work is the finishing of the home product.

Notwithstanding the enormous progress this branch of the industry has made during the last five years, it is yet in its infancy. The only disquieting circumstance is the injudicious and wanton depredation of the shell deposits. The beds in front of Muscatine, Iowa, are already exhausted, and unless something is done to protect the mussels it will not be long before the raw material for this industry will be exhausted.

* The material for this article was extracted from a monograph by Axel Josephson, published in Census Bulletin 172. The photographs were kindly lent by Mr. J. F. Boepple, of Muscatine, Iowa.

ITALIAN BELL-TOWERS.*

"Campanile," in Italian, has the same signification as "bell-tower," in English, *clocher*, in French, and *Glockenthurm*, in German, and the oldest bell-towers of Italy hardly date back beyond the fifth century. This is proved by the mosaic on the triumphal arch of Santa Maria Maggiore at Rome, a work of the time of Sixtus III. (430-40), where towers rear themselves alongside a baptistery and basilica; and even on the celebrated wooden doors of S. Sabina at Rome there exists something which seems to be a tower (these doors are of the fifth century, of the time, as it appears, of Celestin I., or about 422-32). But we are not at all certain that these towers had bells in them, so one ought to call them simply towers, or *torri*. It is certain, all the same, that bells were in use in Italy in the eighth century, during the pontificate of Stephen VII. (752), who in giving bells to the Vatican Basilica must have introduced their use into the Eternal City in the middle of the eighth century. This statement of Amalario's, Bishop of Treviri, a contemporary of Charlemagne, cannot be accepted without some reservation. However that may be, at present, the most ancient bell in Italy, that of the Museo Falconi at Viterbo, has been acknowledged to belong to the eighth or ninth century, and it is, in truth, an article of venerable antiquity. It is very simple, this bell of the Museo Falconi, as it has no artistic pretense whatever unless in the general mass, which has a certain elegance of line and the peculiarity that there is a triangular hole and an engraved design which De Rossi, prince of Christian archæologists, believes to be the roof of a three-nave basilica. Add a cross to the curved extremities characteristic of the seventh and eighth centuries, and you will have an image of the general appearance of the Falconi bell as it was exhibited for the last time at the feast of the Eucharist, at Orvieto, in 1896.

Well, though I ought only to speak here of bell-towers, allow me to say that De Rossi compares the Falconi bell to a certain representation in the codex at the Library of Bologna, whose assignment to the ninth century has not yet been seriously disputed.

Now let us come to the monuments.

In Italy there are very few churches with bell-towers on the flanks of the façade or rising near the apses. In Sicily there are the cathedrals at Cefalu and at Monreale. In Apulia—a monumental corner of the Peninsula very little known—are the cathedrals at Altamura, Molfetta and Bari; in Æmilia, the cathedral at Borgo S. Domino; in Lombardy, the churches of S. Ambrogio and S. Sepolcro at Milan, as well as S. Abbondio at Como; in Piedmont there is S. Andrea at Vercelli; in Liguria, the Cathedral of Genoa, one of whose towers is still unfinished. In other countries, on the contrary, limiting myself to old Europe, church façades with two towers are numberless, and are found in France, Germany, England, among those in the Romanesque and Gothic styles.

In the same way, in Italy, there are very few churches with more than two towers, as we see in the case of the cathedral at Palermo and at Borgo S. Donino, and fewer still are those with a single tower in the middle of the façade, as in the case of the churches of S. Maria del Tiglio, at Gravedona (Lake of Como) and S. Matteo in Campo d'Orto, at Perugia. So, with us, almost all churches have single bell-towers, and some that are isolated, but erected quite near to the church building. In this last category may be mentioned the cathedrals at Pisa and Florence, the Church of S. Zeno at Verona and St. Mark's at Venice.

The oldest bell-towers on the Peninsula are surely the Byzantine ones at Ravenna, round like that of S. Apollinare in Classe, which is the most beautiful of the Byzantine towers of that city, which might be called an Italo-Byzantine Pompeii. The tower of S. Apollinare in Classe dates to the same epoch as that of S. Apollinare Nuovo at Ravenna, generally given as the eighth century, but in my opinion it is still older. A beautiful round tower of the same kind is that of SS. Giovanni and Paolo, also at Ravenna, lately brought out into sight by means of reasonable restorations. In short, the Byzantine towers of Ravenna by reason of their form or by their construction are remarkable specimens of the most ancient bell-towers in Italy. This emphasizes the fact that with us the most ancient bell-towers were often round. A tower of this same form that is very little known, even to Italians, is to be found at Caorle, in Venetia, and it is to be regretted that I could not obtain for you any photograph of it. But I can give a reproduction of the bell-tower of S. Satiro at Milan, justly considered the oldest of the square bell-towers, the square form having remained characteristic of almost all of the Italian bell-towers. This is a structure of the ninth century, of serious character and simple motive, one of those monuments which are always preserved with the greatest care. Milan and Lombardy possess several of the finest Italian bell-towers, among others the tower called "dei Monaci" of the basilica of S. Ambrogio, which, from the historical point-of-view, has many rights to be mentioned here. But for artistic towers we must leave the centuries earlier than the year 1000, and turn to the eleventh, twelfth and thirteenth centuries. It must be remarked, however, that some among these towers which date back beyond the year 1000 one would like to call older yet. This, also, might be said of several of the mediæval churches in Italy. For example, I will mention S. Maria in Cosmedin at Rome. This tower, of a perfect elegance and exquisite air, is indeed attributed to the eighth century, but, for me, it belongs to the twelfth. By the side of this celebrated tower we will find in Rome that of S. Maria in Trastevere, which dates from the time of Innocent II. (1130-43), and also that of S. Maria Maggiore, the origin of which does not go back farther than the twelfth century. It is evident that this tower has been restored, and history tells us that these restorations took place in the times of Gregory XI. (1370-78) and Paul V. (1605-21). Bell-towers are typical of the Eternal City, and one must bear this in mind. Rome possesses other remarkable towers—those of SS. Giovanni e Paolo, a work of the twelfth century, and S. Croce in Gerusalemme, built at the end of the same century, a century which inspired the architect of the tower of S. Spirito in Sassia who, like the modern eclectic architect, introduced forms belonging to the full Renaissance. This brings it about that this architect dressed up a mediæval organism in details belonging to the fifteenth century.

The centuries following the year 1000 have brought us to the more celebrated towers of Lombardy, Æmilia and Tuscany. Here we are before the "Torrazzo" at Cremona, admirable in its elegance and in its fineness of ornament, a *chef d'œuvre* of great renown, which surpasses, and by much, that of the city in which the tower rears itself, where it is esteemed like a jewel in its casket. This is entirely a brick structure, a material greatly used in Lombardy and Æmilia. The history which relates to the Torrazzo most often is based on ancient traditions which have nothing of serious value belonging to them. The real truth is this: the tower of Cremona cannot date back to the eighth century, and the old writers deceived themselves, since historic reasons, as well as those of art and construction, demonstrate that the Torrazzo was begun in the twelfth or thirteenth century and was finished about the end of the same period, as it appears, since we know that in 1267 the square part was finished. Unfortunately we do not know the author, or the authors, of this Torrazzo, considered the marvel of Cremona, as are the leaning tower of Pisa and "La Ghirlandina" of Modena, of which I will speak after having criticised the graceful tower of the cathedral at Crema, which resembles, in its crowning stories, the Torrazzo at Cremona and the tower of S. Gottardo at Milan, one of those jewels which the Middle Ages left as a heritage and which we preserve with pride.

The tower of S. Gottardo is composed of several stories, crowned by a conical roof carried on a circular colonnade, and the brick and the discreet polychromy give it a decorative aspect which is very striking. Its author was a Cremonese, "*Magister Franciscus de Pecoraris de Cremona fecit hoc opus*," and its date the first half of the fourteenth century, which speaks to us of an age extremely happy for Italian fabrication.

In accordance with Italian Chauvinism "La Ghirlandina," that is to say, the tower of the Cathedral of Modena, is the peer of the Torrazzo, but the tower at Modena is very far from possessing the beauty of the Torrazzo. The Modenese, however, do not esteem their tower any less than the Cremonese esteem the tower of their cathedral, for in certain Italian towns there exists a true communal pride in their own monuments, and very often the most remarkable monuments are used as symbols of the city. The lower or square portion of the Ghirlandina was built, it appears, at the same time with the cathedral, and finished in 1159. Above this portion of the structure rise the octagonal and pyramidal portions which were built between 1261 and 1319, according to the plans of Arrigo da Campione. Lately, the restorations carried out on the tower at Modena have cost the city a large sum.

Near Modena, at Bologna, in Æmilia, the towers "degli Asinelli" and the "Garisendi" enjoy the highest reputation. The first belongs to 1109, the second to 1110. These are two leaning towers, but civil and not ecclesiastic, as are the others which are the subjects of this article. They can, nevertheless, be brought to mind here, before speaking of the celebrated leaning tower of Pisa, the tower of the most famous and superb cathedral in the Romanesque style in all Tuscany.

Everybody knows the "Campanile of Pisa," better known for its inclination, perhaps, than because of its open loggia treatment, too much repeated. It was finished in 1174 by the architect Bonanno, and, most often, like the towers of Bologna, it is admitted that its inclination is accidental. Upon this subject we can remark that when the inclination was discovered in the lower vaults the architect endeavored to apply a remedy, and history tells us that during a certain length of time the work was stopped and it was then that the architect was changed. Bonanno was replaced by Guglielmo of Innsbrück, who did not, however, continue the work to the end, as the tower was finished by Tommaso da Pisa, to whom reverts the honor of having placed upon the summit of the tower a bell-chamber.

Its departure from the vertical is very noticeable, being 2.40 meters, and the question whether the inclination was accidental or intentional has been frequently discussed. The last author who has resolutely willed to hold himself apart from the generally accepted opinion is your Professor Goodyear, who, in his remarkable studies on the refinements of Italian architecture of the Middle Ages—studies only just current in Italy—has not hesitated to profess his belief that the displacement of the tower of Pisa is one of those effects of art, one of those *bizarreries* in which the architecture of the Middle Ages abounds. Professor Goodyear points out that even on the façade of the Cathedral of Pisa there exists a certain displacement from the vertical and then a return to the vertical, and this North American writer, who has a love for such subtilties, as Pennethorne and Penrose had for those of Greek architecture, brings together such a quantity of facts drawn from our architecture of the Middle Ages that one must listen to him with the most respectful deference; this I shall do here, and I shall do so elsewhere, in the fourth edition of my "Manuale d'Architettura Italiana," which I hope will be brought out in the first months of the coming year.

Quite near Pisa are Lucca, Pescia and Pistoja, whose respective cathedrals have important towers. The tower at Pescià, unfinished and dating from the middle of the fourteenth century, is very little known. Its robust and simple construction, which does not deprive it of grace, urges me to exhibit it here, but I am far from according it the importance which the pretty tower at Pistoja deserves. This tower, which rises square in plan to the very top, recalls the open loggia treatment of the campanile at Pisa, although at Pis-

* American Architect.

toja the use of these loggias, common to the Romanesque architecture of Tuscany, is more modest. The decoration of the tower, in white and dark-green marble, gives it an air of lightness while preserving to it its imprint of majesty. The author of the tower of Pistoja is not known as are the authors of the campanile at Pisa, but his style indicates the epoch, the end of the thirteenth century or the beginning of the one following.

The railroad leads from Pistoja to Florence in forty minutes. Florence possesses the most celebrated tower in all Italy, a glorious monument which at once calls up Giotto's name. But is this evocation a legitimate one? This is what we are going to find out after having noted at Florence the tower of S. Maria Novella and that of the Badia (1330), two towers which, while very models, are far from having the beauty and the richness of Giotto's tower.

The tradition of ages gives to Giotto the honor of being the architect of the campanile which rises at the side of the Cathedral of Florence and, although this tradition may be devoid of all authenticity, in Italy, at least, one cannot separate the campanile at Florence from the name of the reviver of Italian painting.

It is very sure that Giotto laid the foundations of the tower in 1334, but, dying in 1336, he was replaced by Andrea da Pisa, who ought to be called Da Pontedera; but this master, whose place in the history of art is that of a sculptor and in no way that of an architect, was dismissed, because he desired to introduce certain changes in the tower. It was then that the Florentines entrusted the direction of the work to Francesco Talenti, the real architect of the campanile of Florence; that is to say, the architect of the upper stories, the most beautiful and glorious portions of the construction.

Among the Italian artists of the Middle Ages in the architectural field, Talenti was in very truth one of the most distinguished and the most forgotten, and that one of the writers upon art who shall produce a study of this Florentine artist will exhibit to the public and students of art a new architect of real genius where there was believed to be one merely of the second rank. Talenti accepted the direction of the work on the Florentine tower at the time when that work was hardly begun, and having finished it his name should take the place of that occupied by Giotto. It is not probable that Talenti followed the drawing of the immortal painter, which might be identified with that which is found on a parchment in the Cathedral of Siena, a design which is strikingly grotesque in taste.

I regret that a general study such as this is does not allow me to stop longer on these particular matters. I beg the reader, therefore, to believe that my affirmation is supported by facts.

I turn now to Southern Italy, and in Apulia we find the tower of Trani, a monument of particular importance because it is signed by an artist who has some points of resemblance with Talenti, as being long forgotten. This is "*Nicolaus sacerdos et protomagister*," who built a great portion of the tower, finished in the second half of the fourteenth century. In Apulia, also, admirers of towers will find at Bitonto the campanile of S. Leo, a work of the thirteenth century, simple, logical, robust and elegant. I do not refer to the towers of the Cathedral at Bitonto, renewed in the fifteenth century, the origin of which dates back to the first quarter of the thirteenth century.

I turn now to Sicily, whose mediæval architecture has a peculiarly Arabo-Byzantine-Norman-Sicilian, eclectic air; in a word, pervaded by an eclecticism, which passes all prevision, and produces in the history of architecture a page full of attractiveness and charm. Of this you will gain an idea from the illustration of the towers of Monte S. Giuliano and of Girgenti in the first place.

Everywhere here the pointed arch appears in full twelfth-century work, and we see in this pretty fragment of the tower of the Cathedral of Girgenti ogee arches, arches, that is, formed by two curves having different directions, and we can remark in this same fragment the zigzag decoration in the archivolt of the topmost window. Here it is necessary to remark that it is not a matter of an isolated motive, but of a motive which is very widely scattered in Sicilian architecture, the Norman origin of which cannot be put too much in evidence. This kind of ornament was preserved in Sicily up to the end of the fourteenth century, and I believe that the fragment we have before us belongs precisely to that epoch.

The most important Sicilian bell-tower, however, is that of the church called the Martorana, at Palermo. The construction of the tower is intimately connected with that of the church, and the church, which, as well as the Palermitan bridge over the Oreto, was built in 1143 by Giorgio d'Antiochia, a celebrated dignitary of the Norman court, was richly endowed in 1146, and before taking on the name of Martorana was called S. Maria dell' Ammiraglio, a name which has been preserved to this day. In time, to the old church was annexed a monastery, founded by Aloise Martorana, which brought about the change of name, and in the sixteenth and seventeenth centuries changed greatly its physiognomy.

Among the portions preserved is the tower, which presents a picturesque *ensemble* of a kind quite new for the Italians of the Continent. It is the upper stories which most generally are appreciated, and travelers ought to examine the details and, above all, the pretty capitals.

At Palermo, when visiting the Cathedral, one is impressed by the towers which surround it; at the beginning of this paper I pointed out that the Cathedral of Palermo was one of those rare Italian monuments decorated with several towers.

At length, taking our way northward, after the Gothic tower of the Cathedral of Albenga, near Genoa, one of the most beautiful in Liguria, after the tower of S. Agnese in Genoa, dating from 1260, and, on the north side of the Peninsula, after the tower of the Abbey of Pomposa, a monument which even in Italy has remained too much unknown, I take my leave of the subject by drawing attention to the ruined Tower of S. Mark at Venice. A leaning tower, this one, too, but not sensibly, as in the case of the towers of Bologna and Pisa, but which possessed the strange peculiarity of having no stairs. Instead of staircases, there were inclined planes, on which you could ascend to the top of the Venetian tower afoot, on horseback or on bicycle if you would. It was enough to cast one's eyes over the monument to perceive that it belonged to two epochs profoundly different, and that the tower of S. Mark's, begun before 948, was begun anew in that year, according to some, or in 1068, according to others, or in 1147, according to still others, and in the course of the centuries underwent several periods of construction before its completion. The records speak of works dating back to 1310, to 1489, to 1511; in fact, in 1489 a thunderbolt struck the tower, and Giorgio Spavento designed the restorations, and in 1511 a thunderstorm again damaged the structure. It was then that the Tower of S. Mark received the upper stories, according to the plans of Bartolomeo Bon, of Bergamo.

To point out one more interesting detail: it was pretended that the foundations of the tower were as deep as the tower was high, and likewise that these foundations were star-shaped in plan. Although these assertions are found in books and are widely disseminated, I draw attention to the fact that during the excavations carried on in 1865 it was learned that the foundations of the Tower of S. Mark are not over 5 meters deep, and there is nothing remarkable in such a depth as this. ALFREDO MELANI.

THE WORLD'S DEBT INCREASES.

THE Matin of Paris says: In 1801 the world's debt amounted to \$3,000,000,000; in 1848, after the Napoleonic wars, it was \$8,400,000,000; in 1901, \$31,800,000,000. It increased within the last century by \$28,800,000,000; but whereas during the first part of last century, notwithstanding the gigantic wars which then unsettled part of the world, it increased but at the ratio of 3 to 1, the increase during the second part was at the ratio of 10 to 1.

Toward this increase each nation has contributed with all its power. Only two nations preserved coolness. Great Britain, which during forty years reduced its debt by \$1,000,000,000, and the United States, which reduced its liabilities by over \$1,400,000,000.

The Austrian debt, which in 1850 was but \$600,000,000, reaches at present \$1,700,000,000; the debt of Germany has grown from \$116,000,000 in 1870 to \$559,000,000; that of Italy, which in 1869 was \$1,400,000,000, is now \$2,583,000,000; the debt of Russia, which in 1853 was \$400,000,000, exceeded in 1900 \$3,000,000,000. France is easily winner in this contest; her debt, which in 1852 was little over \$1,000,000,000, amounts to-day to about \$5,800,000,000, or almost six times the amount in the former year, constituting almost one-fifth of the total world's indebtedness.

The debts of the Germanic and Slavic group of nations the last quarter of the century have been due chiefly to the purchase or construction of railways, and they possess in these "physical" capital which almost equals their total debt, and derive therefrom a revenue almost sufficient for the service of this debt. Quite a different picture is presented by the Latin nations. These have within the last twenty-five years increased their debts by \$5,000,000,000, Spain and Italy very nearly doubling their debt, France almost trebling hers. In return they cannot be said to have acquired any well-defined material assets. France particularly, which perhaps spent more than any other nation has on her railways, will have to wait until 1954 to acquire ownership of them.

PROGRESS OF UNITED STATES IN MATERIAL INDUSTRIES.

A MOVING picture of conditions in the United States at decennial intervals from 1800 to 1850 and annually from 1850 to 1902 is presented in a monograph just issued by the Treasury Bureau of Statistics entitled "Progress of the United States in Its Material Industries." This monograph consists of a series of tables showing area, population, wealth, debt, money in circulation, banks and bank clearings and depositors, farms and farm values, manufactures and their value, revenues, expenditures, imports, exports, railways and their business, the shipping industry and many other features of national development, in the census years from 1800 to 1850 and annually from 1850 to 1902. The figures presented, regarding more than one hundred subjects, show an interesting, and in many cases a phenomenal growth in the industries, finances, production and transportation of the country. The area has grown from 827,844 square miles in 1800 to 3,025,600 square miles in 1902, exclusive of Alaska and the islands belonging to the United States. The population per square mile, which was 3.6 in 1810, was 26.1 in 1902, notwithstanding the great increase in area meantime. The total wealth has grown from \$7,000,000,000 in 1850 to an estimated \$94,000,000,000 in 1900, and the per capita wealth from \$307 in 1857 to \$1,235 in 1900. In no feature has there been greater fluctuation perhaps than in the public debt and interest charge. In 1800 the public debt was \$15 per capita; in 1840 it had fallen to 21 cents per capita; in 1852 it was \$2.67 per capita; in 1861, before the beginning of the war, \$2.74, and then mounted rapidly until it became \$76.98 per capita in 1865, gradually falling again after the war to \$38.27 in 1880, \$14.22 in 1890, \$12.64 in 1893, \$13.60 in 1896, and \$12.97 in 1902. The money in circulation amounted to \$13.85 per capita in 1860, touched \$20.57 during the period of paper currency near the close of the war, but again fell below the \$20 mark until 1881, when it rose to \$21.71 per capita. By 1892 it had reached \$24.60 per capita; in 1896 it was \$21.44, in 1900 \$26.93, and in 1902 \$28.40 per capita, the highest point that it has ever reached. Deposits in savings banks amounted to \$1,138,576 in 1820, \$6,973,304 in 1830, \$43,431,130 in 1850, \$149,277,504 in 1860, \$549,874,358 in 1870, \$819,106,973 in 1880, \$1,524,844,506 in 1890, \$1,810,597,023 in 1895, and \$2,597,094,580 in 1901. Meantime the individual deposits in national banks had grown from \$500,910,873 in 1865 to \$3,111,690,196 in 1902.

The cause of these financial conditions above noted—the increase of currency, bank deposits, etc.—is found in other tables showing the development of farms, manufactures and of the various industries. The number of farms increased from 1,449,073 in 1850 to 5,739,657 in 1900, the value of farms and farm property from \$4,000,000,000 in 1850 to \$20,000,000,000 in 1900, and the value of their product, which was not measured until 1870, grew from \$1,958,000,000 in that year to \$3,764,000,000 in 1900. The value of farm animals increased from \$544,000,000 in 1850 to \$2,981,000,000 in 1900. The value of the product of the manufacturing industries grew from \$1,000,000,000 in 1850 to \$13,000,000,000 in 1900, while the number of people employed therein grew from less than 1,000,000 in 1850 to 6,750,000 in 1900.

The following table shows the figures for a few of the more important columns of the monograph, for the years 1890, 1895 and 1902:

	1890	1895	1902
Public debt, less cash in Treasury	\$890,784,370	\$901,672,966	\$969,457,241
Money in circulation	\$1,429,251,270	\$1,601,968,473	\$2,246,529,412
Bank clearings	\$58,845,279,505	\$50,975,155,046	\$1,190,226,021*
Deposits in savings banks	\$1,524,844,506	\$1,810,597,023	\$2,597,094,580*
Deposits in national banks	\$1,485,095,856	\$1,720,550,241	\$3,151,690,196
Number of farms	4,564,641	not stated	5,739,657†
Value farm products	\$2,460,107,454	not stated	\$3,764,177,706†
Value farm animals	\$2,418,766,028	\$1,819,446,306	\$2,981,054,115†
Coal produced (tons)	140,866,981	172,426,366	261,677,961*
Steel produced (tons)	4,277,071	6,114,834	13,473,595*
Manufacturing industries: Average No. employés	4,712,622	not stated	5,719,137†
Wages and salaries paid	\$2,283,216,529	not stated	\$2,735,430,848†
Value of products	\$5,369,579,191	\$9,372,437,283	\$13,039,279,566†
Iron and Steel industry: Wages and salaries paid	\$95,736,192	not stated	\$134,739,004†
Value of products	\$478,687,519	not stated	\$835,759,034†
Railways in operation (miles)	166,654	181,065	201,839
Freight carried one mile (tons)	620,439,082	529,766,259	584,695,935†
Rate per ton per mile	\$0.93	\$0.84	\$0.75†

* 1901 † 1900

TOADS IN FOLKLORE.

No animal could be more unlike a swan than a toad, yet the latter also has a prominent place in folklore. Perhaps such honor is primarily due to the very ugliness of the creature, just as it has been affirmed that next to personal beauty a reverse aspect may find favor with the fair sex, the main point being to impress the memory. At any rate, we find the toad distinguished in popular tradition, and that in its most permanent province, in local worship and belief. The survival is so strange in itself and so well fitted to illustrate the primitive character of fairy mythology that it may be accorded particular attention.

According to the statements of Dr. G. Pitre, contained in his excellent account of Sicilian tradition, the faith of that island still recognizes supernatural beings known as Donne di Fuora, Ladies from Abroad, also entitled Patronesses of the House, who have attributes in common with the fairies of England. Like the latter, during the night time they enter houses, where they expect to find everything in order; among mortals they have their favorites and enemies; fortune is considered to result from their kindness, sickness and poverty from their persecution. It is a peculiar feature of their habits that they visit the domicile not on any evening indifferently, but only on Thursday, making their entrance by the keyhole or by cracks of doors. If day surprises them before they leave the cottage, they change into toads, and in this state remain until the following eve, when they are once more at liberty to resume their proper shape of beautiful women. During the interval the toad is sacred, because it is impossible to be sure that any particular one may not be the Lady of the House.

Legends abound in which are related the reward or punishment consequent upon the good or ill-treatment of a Friday toad; on this day, therefore, the usually unpopular animal is safe from abuse and secure of attention, more especially if it chance to belong to a species possessing a particular arrangement of the cuticle reminiscent of a lady's head of hair. Any person who occupies himself with folklore becomes accustomed to remarkable survivals; yet it does excite astonishment to find so perfect an illustration of prehistoric thought in central Europe of the twentieth century.—International Monthly.

WHY AUTOMOBILES ARE UNPOPULAR IN MOROCCO.

CONSUL LANGERMAN, of Tangier, who has been on leave of absence, gives the following explanation of why Muley Abdul Azziz, Sultan of Morocco, prohibited automobiles in his country:

"The French government presented a fine automobile to the Sultan, and sent over an expert chauffeur to run it for him. The potentate was charmed by the new means of covering the ground, and it looked as though horses and state carriages would go to the stable for good. But one day when the Sultan was spinning along a road, the machinery got out of order, and the carriage escaped from the chauffeur's control. Then a tire exploded, and the steering gear refused to work. The machine ran away. The Sultan called upon it to stop, but it refused to obey. The chauffeur saw death ahead whether the inevitable accident was fatal or not. Then the machine struck a rock, and both the Sultan and the chauffeur were launched into space, while the automobile turned over with the wheels still spinning. The Sultan was not badly hurt, but he limped back to town and sent the royal blacksmith out with the royal sledge hammer to smash the royal auto to royal smithereens. Then he forbade by an edict, an order, a ukase, a law, a proclamation, and a bull, that any of his subjects should ever import or use an automobile."

SAMSONS OF THE KEYBOARD.

SHAKESPEARE, with the prophetic insight of genius, must surely have had in mind the modern pianist when he wrote that "the labor we delight in physics pain." How many—or, rather, how few—of the tens of thousands who find pleasure and profit in the control of the "five-and-thirty black slaves, half a hundred white," of our well-beloved domestic orchestra, are cognizant of the fact that the rendition of a classical piece of the average length of 200 bars calls for an outlay of muscular force equivalent to the lifting of a weight of 500 pounds avoirdupois?—a statement which reads more like a record achievement of the renowned Samson than anything else. Keeping this startling fact in mind, it is obvious that the lightness or heaviness of touch provided by the obliging piano maker of to-day becomes a matter of the first importance to the player of moderate physique. Moreover, the degree of this touch-resistance has fluctuated greatly during the strange, eventful history of the "Forte-Piano, or Hammer Clavier" (as it was styled at the time of its invention in the year 1710), as the following figures clearly show:

	Oz.	Dr.
Weight required to depress the lowest C of the horizontal grand piano of 1760	1	8
Ditto for grand of 1877	4	0
Ditto for grand of present time	2	10

The degree of touch-resistance last given—the one adopted by our leading English makers of to-day, in both their horizontal and uprights—may be justly regarded as representing quite an ideal standard; one which, while avoiding that heaviness and stiffness which soon become fatiguing to the player, provides sufficient of elastic resistance to assist the fingers in that bewildering steeplechasing over the keyboard characteristic of our present thunder and lightning school of piano music. It is worthy of mention that no inconsiderable proportion of the muscular and nervous force called for in the rendition of a piece is dependent upon the construction and character of the "action," which, in these days, has been brought to a high pitch of mechanical perfection.—The Piano Journal.

RETURN STEAM TRAP.

THE accompanying illustration represents a sectional view of a new form of return steam trap which has just been introduced. It is made under Shackleton and Flather's patent by Royles, Limited, of Iriam, near Manchester. This trap claims to be ahead of all others in respect of simplicity of mechanism and reliability of action. The apparatus may be described as follows: Figs. 1 and 2 are two views of the trap. *A* is a circular copper vessel or float, contained in a circular cast iron case, *B*. It is provided with a centrally placed vertical spindle, *C*, which acts as a guide rod, sliding in bearings top and bottom. The top of the rod is prolonged and serves two purposes. It has fitted to it an equilibrium valve which covers and uncovers the ports, *E* and *F*, in the valve box, *G*. A further prolongation of the spindle takes it through a stuffing-box, where it is connected through a link, *J*, with the tumbler action, *H*, which is a device designed to give a positive action to the valve, *D*, so that it does not entirely depend upon the movements of the float to actuate it. It consists of a frame, *H*, which is pivoted at *I*, and contains a roller, *K*, which, though it can roll from end to end of the frame, cannot escape from it. The precise duty of this roller will be described in more detail later on. *L* is a siphon pipe dipping down into a recess in the bottom of the float, *A*, and connected through the branch, *M*, to the check valve, *N*, and thence direct to the boiler. On the other side of the case there is a further check valve, *O*, through which the condensed water enters the trap.

It is essential for the proper action of this trap that it should be fixed not less than 4 feet above the level of the surface of the water in the boiler. The connection from the valve, *N*, to the boiler must enter the latter at some place below the water level. There is also a steam connection from the boiler to the port, *E*, of the valve, *D*. It is important that this pipe should be connected direct to the boiler, as full boiler pressure must be in this pipe. The action of the trap is as follows: The condensed water enters through *O* and gradually fills *B* to such a height that it overflows into the float, *A*, and causes it to descend, carrying the spindle, *C*, with it. This opens the port, *E*, allowing steam to enter the trap from the boiler. The downward motion makes the roller, *K*, tend to assume the position shown by the dotted lines, and it is this which gives the positive action to the valve and closes the port, *F*, which previously had been freely open to the atmosphere. When the steam enters the case, *B*, there is obviously an equilibrium of pressure between it and the boiler, and there is hence no reason why the condensed water should not flow by gravity into the boiler, which, in fact, it does through the siphon pipe, *L*, and the check valve, *N*. This action restores the buoyancy to the float, *A*, which rises and causes the port, *F*, to be opened to atmosphere, and the port, *E*, to close so that the supply of boiler steam is cut off. Meanwhile the roller, *K*, rolls to the inner end of the frame, *H*, thus lightening the load in the bucket and insuring a positive movement of the valve. As soon, of course, as the steam pressure within the casing discharges itself to atmosphere the condensed water again begins to enter the trap and the cycle of operations is continued. This trap may either be used in connection with a general hotwell or cistern, or it may be joined direct to the drip, if there is but one, or to a general receiver into which the various drips—if there are more than one—are led. It will be observed that no reliance is put in this trap upon differences of temperature, and there appears to be no reason why it should not work most successfully.—The Engineer.

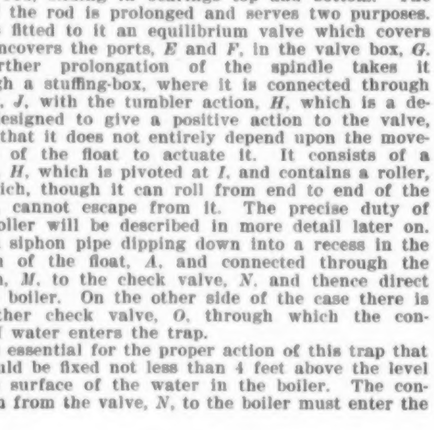


FIG. 1.—RETURN STEAM TRAP.

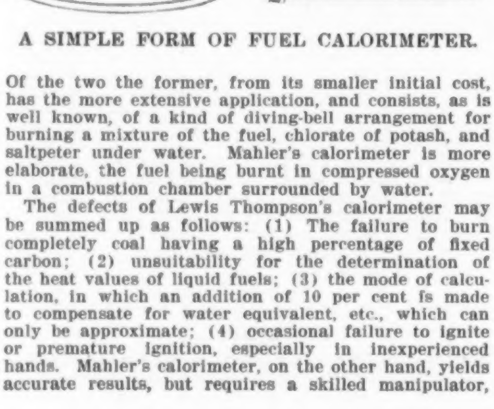
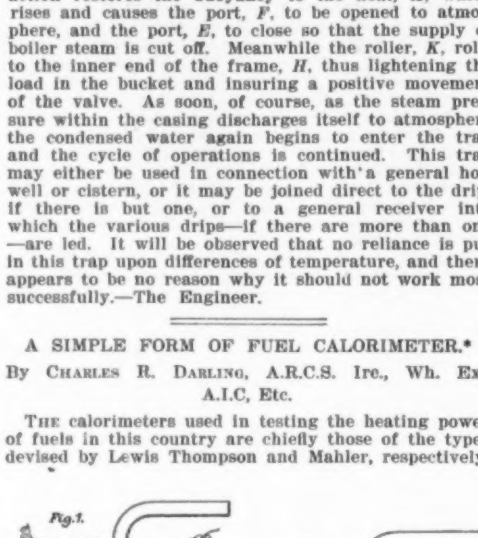


FIG. 2.—SECTION OF STEAM TRAP.

A SIMPLE FORM OF FUEL CALORIMETER.*

By CHARLES R. DARLING, A.R.C.S. Ire., Wh. Ex., A.I.C, Etc.

THE calorimeters used in testing the heating power of fuels in this country are chiefly those of the types devised by Lewis Thompson and Mahler, respectively.



A SIMPLE FORM OF FUEL CALORIMETER.

Of the two the former, from its smaller initial cost, has the more extensive application, and consists, as is well known, of a kind of diving-bell arrangement for burning a mixture of the fuel, chlorate of potash, and saltpeter under water. Mahler's calorimeter is more elaborate, the fuel being burnt in compressed oxygen in a combustion chamber surrounded by water.

The defects of Lewis Thompson's calorimeter may be summed up as follows: (1) The failure to burn completely coal having a high percentage of fixed carbon; (2) unsuitability for the determination of the heat values of liquid fuels; (3) the mode of calculation, in which an addition of 10 per cent is made to compensate for water equivalent, etc., which can only be approximate; (4) occasional failure to ignite or premature ignition, especially in inexperienced hands. Mahler's calorimeter, on the other hand, yields accurate results, but requires a skilled manipulator, and is extremely high in price. In neither instrument is the progress of the combustion visible or under control.

The desirability of some simple form of calorimeter in which the fuel may be burnt in oxygen gas, and which would yield constant and accurate results, has frequently occurred to the author during an extended experience of fuel-testing. For the purpose of comparing the calorific values of a number of samples, the degree of accuracy obtainable with the Mahler calorimeter is not of great service. The precise value is often of less importance than the knowledge of which of a set of samples is the best. Nor is extreme accuracy necessary in testing samples obtained from a given source at different times, as any noticeable alteration in quality could be detected by any instrument yielding constant results. With these considerations in view, the author has made numerous experiments with many varieties of calorimeter, and, as a result, is able to recommend the form of instrument illustrated in the accompanying sketch, which possesses the advantages of simplicity in working, a visible combustion completely under control, and considerable accuracy. It has been adapted for commercial purposes by the author from a type of calorimeter which has been in use for some years in the physical laboratory of the Finsbury Technical College. The apparatus consists of a circular brass plate, *A*, supported on three brass legs. The thin-walled brass tube, *D*, about 1 inch in diameter, passes through the center of *A*, and is continued to the chamber, *C*, which is composed of two flat brass plates screwed together, the upper plate being hollowed out and perforated with numerous fine holes, as shown in the section. A recess turned in the plate, *A*, contains a rubber ring; and a glass cover, *E*, furnished with a ground flange at one end and terminating in a neck at the other end, rests with its flange on the rubber ring. It is held in position by means of the brass ring, *B*, which is screwed down on to the flange by means of the milled nuts, *F F*. A second rubber ring is placed between *B* and the blass flange, and on gently turning the nuts a perfectly air-tight joint is secured without danger of cracking the glass. The upper part of the tube, *D*, terminates in three flexible brass tongues, which serve to hold the porcelain or platinum crucible, *G*, in which the sample is burnt. The neck of the flask is fitted with a rubber cork, through which the thick copper wires, *H H*, are passed, and these are connected in the crucible with a thin piece of platinum or iron wire so as to form an electric ignition. Through the center of the cork passes a piece of glass or metallic tubing, preferably widened at the extremity, and reaching to the level of the rim of the crucible. The oxygen used in the combustion is delivered through this tube. The total height is 7 inches. The method of conducting the experiment is as follows: An average sample of coal or coke is ground up in a mortar, and 1 to 1.5 gramme is weighed out into the crucible, which is then fixed in position. The cover is placed over the crucible and screwed down so as to make an air-tight joint, and the cork with its connections inserted in the neck. A gentle stream of oxygen from a cylinder or gasholder is then turned on, and the apparatus immersed in the known quantity of water contained in the vessel. The quantity of water taken must be sufficient to immerse the apparatus to the upper part of the neck of the cover, and may be measured in cubic centimeters, each cubic centimeter being called 1 gramme. The temperature of the water is now taken with a delicate thermometer, and ignition commenced by passing a current of electricity through the wires. As soon as the combustion commences, the battery is disconnected, and the burning continues in the stream of oxygen. The escaping hot gases are compelled to pass down the tube, *D*, into the chamber, *C*, out of which they escape in extremely small bubbles, which rise and rest for a time on the under surface of *A*, finally escaping round the sides. This arrangement insures that all the heat carried over from the combustion chamber by the gases is imparted to the water before the bubbles reach the surface. When combustion ceases, the oxygen is allowed to continue passing through until no further rise of temperature is observed, when the previously hot crucible will have been cooled down to the common temperature. The thermometer is now read, after mixing the water, and the calculation made as under:

$$\frac{(\text{Weight of water} + \text{water equivalent of apparatus}) \times \text{rise in temperature}}{\text{Weight of fuel taken}} = \text{calorific power.}$$

If the Fahrenheit scale is employed, the result will be equivalent to the number of British thermal units given out per pound of coal burnt; if a Centigrade thermometer is used, the result will express pound-degree-Centigrade heat units per pound of fuel. The evaporative power is calculated in the usual way, viz.,

$$\frac{\text{B. T. U.}}{967} \text{ or } \frac{\text{lb.-deg.-Cent. units}}{537} = \text{evaporative power.}$$

When a sample of coal is observed to burn with a smoky flame, the combustion should be stopped, and a second sample weighed out and mixed, before combustion, with about one-half its weight of dry kaolin or calcined alumina. Complete burning is then insured.

In testing liquid fuels, 0.5 to 1 gramme is weighed out into the crucible, and sufficient dry kaolin or calcined alumina added to form a stiff paste. The combustion is then conducted as before; but the quantity of oxygen must be carefully regulated in order to prevent smoking. With a little practice no difficulty is experienced with liquid fuels.

The time of combustion should occupy 4 to 5 minutes, and the oxygen should never be admitted so rapidly as to cause the burning coal to blow out of the crucible. When this precaution has been adopted, the residual ash may be weighed, and its quantity thus determined without resorting to a separate experiment.

When an electric ignition is not available, the combustion may be started by placing 0.05 gramme of powdered sulphur in a heap on the top of the fuel. This is ignited by touching with a hot rod before placing the apparatus in the water, the immersion being delayed until the cork and tube have been inserted and a gentle stream of oxygen turned on. The ignition spreads from the sulphur to the fuel; and the heat produced by the combustion of the sulphur may be allowed for in the calculation. When 0.05 gramme is used to start the ignition, a deduction of 200 B. T. U., or 111 lb.-deg.-C. units must be made from the total obtained.

Radiation errors may be minimized by commencing with the water at a temperature lower than that of

* Engineering.

the room by an amount equal to the excess temperature over that of the room at the end of the experiment. Thus, if a total rise of 9 deg. F. is obtained with a given sample, the temperature of the water should be 4.5 deg. F. below that of the room at the commencement. Where greater accuracy is desired, the glass vessel may be replaced by one of copper, which is, in turn, surrounded by a larger copper vessel and shield, as in Mahler's arrangement.

The water equivalent of the apparatus and vessel may be determined experimentally in the usual way. With a glass vessel requiring 1,500 cubic centimeters of water to immerse the combustion arrangement, the water equivalent ranges from 200 to 250 grammes, according to the thickness of the glass. The author is satisfied that the apparatus, in its simplest form, will be found to give excellent results, sufficiently accurate for all ordinary purposes. No difficulty is experienced in conducting a combustion, even by a comparatively untrained operator. The fact that the combustion is visible, and may be slackened or accelerated at will, and that incomplete burning may be detected and remedied, constitute further advantages. The cost of the apparatus, moreover, is small; and the glass cover, if broken, may be renewed with little expense. With care, however, one cover may be made to last for sixty combustions or more. The accuracy of the apparatus, using a copper calorimeter and shield, and a thermometer graduated to read in twentieths of a deg. F., is about 99 per cent, a result comparing favorably with the expensive Mahler calorimeter. With a glass vessel the error would be slightly greater; the results, however, are constant and far more correct than those obtained by Thompson's method.

COTTON MILLS OF THE SOUTH.

DURING the past three months the announcements of the undertaking of new cotton mills and the enlargement of established mills in the South have been more noted than in any other three months since the Southern textile industry received its great impetus more than a decade ago. The revived activity of this year will result in a great advance of industry, and the completion of the numerous plans recently announced will give the South a more prominent position than ever. The Manufacturers' Record publishes this week a table giving the names of these mills, their location and the extent of the new equipment in ten Southern States. That table shows that by far the greater investments of capital in the industry are being made by experienced cotton manufacturers. For instance, during the past quarter of the year only sixteen strictly new mills were announced, with an aggregate of 128,500 spindles and 2,570 looms, representing an investment of $2,570,000. At the same time thirty-five established companies announced additions to their buildings and an increase of 358,632 spindles, representing an investment of about $7,000,000, so that the total for the second quarter of the year is nearly 500,000 more spindles and an investment of about $10,000,000. Many of these mills and improvements are already under contract, and a number of them are under way.

The tendency of Southern cotton manufacturing continues to be toward the production of finer grades of goods. In connection with these additions should be mentioned the formation of a $2,500,000 company which proposes to establish bleaching and finishing plants at different points in the South, the first one to cost about $200,000, soon to be built at Fayetteville, N. C.; the establishment of an extensive denim factory at Greensboro, N. C., and the formation of a company with an authorized capital of $10,000,000, to establish near Kansas City, Mo., a manufacturing community about a mill which will be ultimately equipped with 500,000 spindles and 12,000 looms, with other necessary machinery, to make plain sheetings and other goods to meet the needs of the greater Southwest.

The steady development of the cotton mill industry is one of the influences which have given the white population of the South a greater stay-at-home character than it possessed two or three decades ago. Analyzing the figures of the census of 1900 relating to native whites of the South, the Manufacturers' Record, pointing out that of 15,758,318 white natives of the South, 3,133,310 have moved from the State of their birth, says this restlessness is less than that prevailing in other parts of the country, and much less than it was in the South forty-odd years ago, for the exiles of the South represent 19.8 per cent; of the country outside the South, 23.7 per cent, and of New England, 23.4 per cent.—Nashville American Correspondence.

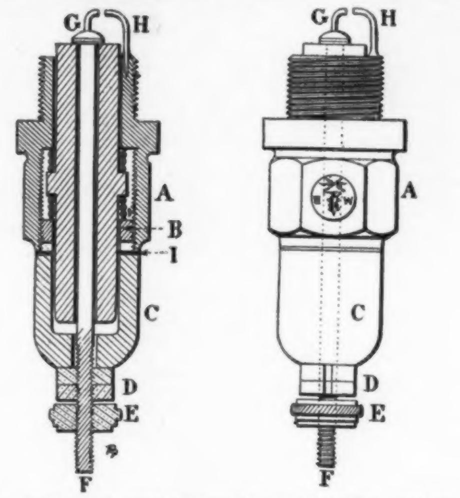
A NOVEL SPARKING PLUG.

THE sparking plug is the most delicate part of a gasolene motor, yet many persons attach to it a relative importance only. The facility with which it can be replaced in the motor, its comparative cheapness, and, finally, the little trouble met with in procuring new ones are the causes of this indifference. Notwithstanding this, inventors are not discouraged, and are all the time making improvements.

One of the latest improvements to be noted is that of a young French engineer, M. Moulin, who conceived the idea of inclosing the exposed part of the porcelain in a cover or hood. By this construction, when the plug is heated as hot as from 300 to 400 degrees, rain may fall on it, or the water of gutters or puddles be splashed over it without causing it to suffer in the least.

This plug will also be found very serviceable for marine engines, for in this kind of service trouble is frequently had from drops of spray lighting on the porcelain and cracking it, which invariably causes a short circuit.

The points, *G* and *H*, are made of a very resistant composition metal and give a good spark in spite of soot caused by oil or a bad mixture. The one set in the shell, *A*, is soldered with silver. The porcelain is insulated in the center of the plug by two joints of asbestos cord. A pressure joint, *B*, checks the escape of any of the gases. The porcelain hood, *C*, is insulated from the shell of the plug by an asbestos washer, *I*, which acts as a cushion for the hood, relieving it of some of the jar produced by the motor. The hood is held in place by two screws, *D*, on the stem, *F*, on



THE MOULIN PROTECTED SPARKING PLUG.

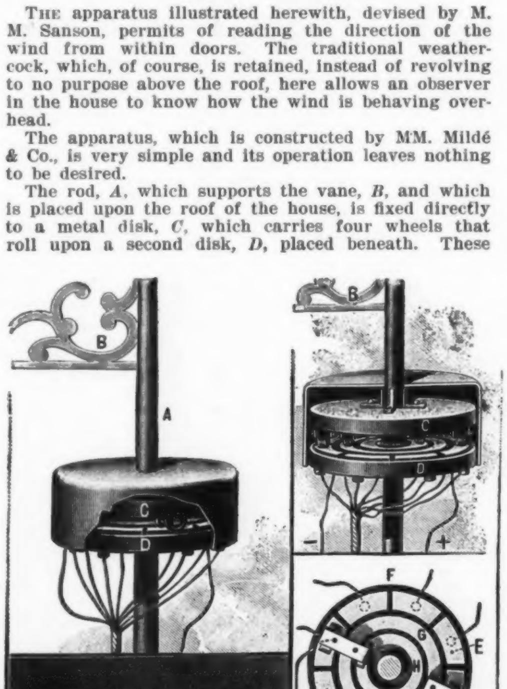
which is also placed the thumb-screw, *E*, for fastening the wire from the spark coil. The plug is constructed without the use of cement, and all parts are interchangeable.—Translated from La Locomotion for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE ELECTRIC ANEMOSCOPE.

THE apparatus illustrated herewith, devised by M. M. Sanson, permits of reading the direction of the wind from within doors. The traditional weathercock, which, of course, is retained, instead of revolving to no purpose above the roof, here allows an observer in the house to know how the wind is behaving overhead.

The apparatus, which is constructed by MM. Mildé & Co., is very simple and its operation leaves nothing to be desired.

The rod, *A*, which supports the vane, *B*, and which is placed upon the roof of the house, is fixed directly to a metal disk, *C*, which carries four wheels that roll upon a second disk, *D*, placed beneath. These



AN ELECTRIC WIND INDICATOR.

disks are inclosed in a box that protects them from external influences.

Upon the lower disk, *D*, are fixed two copper rings, *H* and *G*, which are surrounded by copper plates, *E* and *F*, that are insulated from each other. At the rings, *H* and *G*, end the positive and negative wires of a battery of a few cells. The metal wheels carried by the disk, *C*, are actuated by the vertical rod, and consequently by the weathervane. Upon moving over the rings, *H* and *G*, they establish at every instant, between the latter rings and the external plates of copper, contacts that vary according to the direction of the wind. The various copper plates are connected by wires with the different parts of a Gramme ring, which is placed at a distance on the battery box, fastened to the wall. The result is that the rolling contacts conduct the current in a determined direction to one of the plates, likewise determined beforehand according to the position of the rollers. All the variations in direction that take place in the vane upon the roof are therefore shown by a displacement of the point of contact at which the battery current enters the external copper plates connected with the windings of the Gramme ring. The current upon entering the wire produces in the iron upon which the latter is wound a magnetic pole which will be north or south according to the direction of the current. In order to effect the reading it is only necessary to have placed beside the ring a magnetized needle movable around an axis. The direction of the current sent into the ring must be such that the magnetism it causes in the iron will always be of an opposite polarity to that which exists at the extremity of the needle carrying the indicating arrowhead. As a consequence of this the needle will displace itself immediately and stop over that part of the ring which receives the current; and if the dial is correspondingly graduated, as shown in the engraving, the needle will indicate the principal points of the compass.

There is no complicated mechanism in the apparatus, which may prove useful under numerous circumstances.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

THE INHERENT NATURE OF COHERERS.*

By EDWARD P. THOMPSON.

I THINK I can present evidence to prove that the starting action in a coherer is a spark or sparks produced between the particles of the coherer. A coherer will never operate satisfactorily until it is completely tapped back to its normal condition. Or in other words, the particles which complete the circuit in the cohered condition must be separated before the Hertzian waves will cohere them again. If the particles are separated too far the Hertzian waves will not cohere them again unless increased in cohering power.

I have found, and others have noticed the same effect perhaps, that the looser the particles the higher must be the voltage between the Hertzian wave transmitting terminals. If the coherer is close enough to the transmitter, and if the transmitter is powerful enough, the sparking in the coherer is visible in the dark, and the action of the coherer is very strong. At a distance the spark is so small as to be invisible.

I have performed a radically different experiment with the coherer, independently of any distance Hertzian wave transmitter. I have connected a coherer in circuit with a single cell, and broken the circuit. The coherer was so adjusted as to the looseness of particles, that cohesion did not take place when the circuit was broken. Neither did it take place when two or three or four cells were connected in series through an inductance coil. When, however, a fifth cell was added, there was enough electro-motive force to break down the insulation between the particles, and the resistance became reduced. When the insulation was broken down, of course a spark must have been produced. The above related experiments would show that a coherer cannot be operated until the electro-motive force of the oscillatory current, produced either by Hertzian waves at a distance or by inductance in a battery circuit—until the electro-motive force is sufficient to produce a spark in the coherer.

I have tested my conclusions by comparative experiments with oil coherers, and even with coherers where the insulation is very thin sheet mica. The only difference is that the electro-motive force must be all the greater when the particles are surrounded by a liquid, especially an insulating liquid like oil. The mica coherer will not operate until the electro-motive force is large enough to puncture the mica and form a conducting spark.

If the starting action of a coherer is due to a spark, then a coherer should be more positive in its action if the particles are very close together, and yet definitely separated. To test this point I coated the particles with an exceedingly fine insulating powder. It was intended that the powder should insure minute insulating gaps between the particles, so that a spark would be necessary before the coherer would operate. Such a coherer was tapped back more readily to its initial condition. I am aware that it is not novel to mix an insulating powder with coherer particles. I performed the experiment to be the more sure of a spark-gap. The insulating powder employed was plaster of Paris.

A question which arises is whether a spark can produce any motion of a particle, whereby the sparking in a coherer will bring the particles into contact with one another.

In order to answer this question I made a coherer with only one particle, suspended upon the end of an exceedingly delicate spring, with the particle all but in contact with an electric terminal. A current from a battery sufficient to produce a spark was passed, and a telephone receiver was connected up in circuit. The spark not only attracted the particle to the terminal, but when the circuit was thereby closed the spring pulled the particle away again, and then the action was automatically repeated over and over rapidly, so as to be seen, and so as to be heard as a buzz in the telephone. By having the particle in loose contact, only one cell will cause the action, and the sparking is visible. The telephone acts also as an inductance coil. By doing away with the spring, the particle does not vibrate, but remains cohered to the terminal. Here we have, then, a coherer with only one movable particle, which is at the same time one of the electrodes or terminals of the coherer. Consequently, it seems to be evident that in the ordinary coherer, having loose particles, the action is started by a breaking down of the insulation, the forming of a spark and the attraction of and coherence of the particles to each other.

It is said that a coherer will lose its conductivity after a few hours. Any power that will correspond

* The Electrical Review.

to the spring named above will restore it to its normal condition. To let a coherer stand for a few hours means that the jarring it receives from moving objects decoheres the particles. The mere walking upon the floor will gradually shake the particles apart.

I have performed experiments to show that the local battery current does not pass, unless the particles are in contact or unless the spark conducts the current. The spark lasts but an instant; therefore, the enduring conductivity is due to contact of the particles. Any kind of film will answer that is thin enough for the length of spark produced. A balsam coherer is objectionable, because the particles are not as easily movable as in an ordinary coherer.

Another experiment illustrates that the coherer is actuated by a spark between its particles. Transmit Hertzian waves only sufficient to reduce the resistance very slightly. Now send stronger Hertzian waves. It will be found that these stronger Hertzian waves would have reduced the resistance more if first applied, than if sent for an after-effect of the weaker waves, which latter undoubtedly closed the spark-gap between the particles. After a coherer is once started, it is difficult to reduce the resistance further by additional Hertzian waves, simply because the spark-gap is destroyed, except that there are shunt spark-gaps, but the oscillatory current would take the easiest path, and would need to be of very high voltage to produce more sparks at the shunt spark-gap. Hence, further experiments were instituted to prove this point. Two coherers were placed in parallel. It has probably been noticed by others that such an arrangement is unsatisfactory. Only one coherer "goes off," and the other will not respond to Hertzian waves until the first is tapped. The one coherer was a shunt to the other. The one having the small spark-gap was operated first, and thereby furnished a reduced resistance for practically all the following oscillatory currents to pass through. I found it impossible to cause both coherers to be operated together, except by what might be termed a very large excess of Hertzian waves from a very high-voltage transmitter. The result is evidence of a spark in the coherer closing a spark-gap in another, and leaving the other coherer a shunt of high resistance.

On the other hand, coherers in series operate together, the same as any two spark-gaps in series.

From the experiments thus far noted it becomes possible to explain why a particle follows in the path of a spark, and why the force that sends it is comparatively very great. What is the force, when in the presence of air, whether at atmospheric pressure or rarefied? The spark creates a vacuum in front of the particle, and the air behind presses the particle in the path of the spark. Even in an ordinary vacuum this force would be enough to move a particle through a very minute distance and cause contact, and, by forming contact, cohesive force would maintain contact until tapped. A coherer operates better in a closed tube than in the open air. The spark forces the air to one side from in front of the particle, producing increased pressure in the tube, and therefore behind the particle. These actions may be made apparent on a large scale, as in the experiment with the movable particle. What is true on a large scale would be true in wireless telegraphy at a range of 1,500 miles.

Let the real transmitter of an oscillatory current be a spark-gap opened and closed, and in circuit with a microphone and inductance coil. Sparks will be heard in the microphone, if adjusted till the sound is heard. These sounds are thunder on a minute scale, or explosions of air by the sparks between the carbon granules of the microphone, which, in this case, is a coherer operated by an oscillatory current such as would be found in an aerial wire in wireless telegraphy. A microphone (or coherer with a diaphragm) would, no doubt, produce sound by the action of very powerful aerial Hertzian waves, which would generate an oscillatory current in the aerial wire, and the oscillatory current would produce sparks in the microphone. I am not referring to the case of a magnetic telephone receiver connected up with a microphone, but to the microphone itself, used as a receiver and producing sound.

Finally, sparks are produced in a coherer, because a coherer is, itself, a generator of weak Hertzian waves, as I have proved by an indirect process. A movable needle point resting very lightly against metal forms a coherer. Moreover, an oscillatory current, however delivered, generates Hertzian waves in such a coherer. It is easily accepted that the Hertzian waves could come from nothing but a spark formed in the coherer.

Should any precaution be taken in behalf of the coherer against injurious effects of the sparking which starts coherers into action? No, it is too insignificant. The local current-sparking, however, is an objection, but this is another matter. Anything which will aid the oscillatory sparking is an advantage. Tapping, for example, assists in forming sparking gaps. Increased electro-motive force at the Hertzian transmitter also assists. Inductance coils properly arranged are an advantage. An elementary coherer for wireless telegraphy may, therefore, be defined as a device having microscopical spark-gaps between freely and easily movable minute conducting particles.

Other practical considerations follow. Whatever diminishes the distance between the particles and between the electrodes and particles, without at the same time causing absolute contact, will be of great advantage in the action of coherers, because the sparking distance will be diminished. Some force is needed to hold the particles very near one another and still permit a film of air to prevent contact in the normal condition of the coherer. Such a force is magnetism. I have performed scores of experiments with magnetized particles and magnetized electrodes, and a coherer constructed on this principle seems to throw other coherers in the shade. There is the force of magnetism acting as so much glue to hold the particles continually closer together, and regardless of any exact position of the coherer. One might think at first that the magnetism would itself cause reduction of resistance by cohering the particles. So it does, if too powerful. By placing a permanent magnet near the coherer, it may be moved toward the same until the least Hertzian wave will operate the coherer. Naturally, at first, and before I was convinced of the true nature of coherers, I conjectured that the magnetic field of force was acted upon by the Hertzian wave field of force, the one assisting the other in some very direct way; but there is no reason for such a hypothesis. It is only another piece of evidence that sparks start a coherer into action. The weak magnetic attraction is not sufficient to break down the film of air, but it is sufficient to reduce the thickness of that film to microscopical proportions. The closeness of the particles may, of course, also be adjusted by mechanical pressure, but this is not as reliable as magnetism, for the reason of the absence of attraction or a very desirable form of mild cohesion. The mechanical compression in combination with magnetism produces the happy medium.

CONTEMPORARY ELECTRICAL SCIENCE.*

Spark Spectra.—When the poles between which electric sparks play consist of different metals, variations of the inductance of the circuit produce profound differences in the composition of the light of the sparks. B. Eginitis describes an experiment in which two aluminium wires about 1 mm. thick are covered with a very small quantity of sodium up to a distance of 2 mm. from the end. Sparks are made to play between the poles for a few seconds. They show the spectra of aluminium and of sodium. When the inductance is increased, the aluminium rays rapidly become feeble, whereas the intensity of the yellow sodium rays increases. A small coil 6 cm. in diameter, and with a few turns of wire, suffices to shorten most of the aluminium lines. On further increasing the inductance, the aluminium rays gradually disappear, whereas the sodium rays become still brighter, and eventually become reversed. When the poles are only 1 mm. apart, an inductance of 0.05 henry suffices to eliminate the aluminium spectrum. At larger distances between the poles the inductance required is also larger. Similar results are obtained when platinum, iron, tin and other metals are substituted for aluminium, or when potassium is substituted for sodium. In the case of iron, however, the spectrum reappears at very high inductances. The spectra which persist are those of the more volatile metals.—B. Eginitis, Comptes Rendus, April 14, 1902.

Preparation of Radio-Active Substances.—J. Elster and H. Geitel give a detailed description of the preparation of radio-active surfaces by exposure to the air. The apparatus is comparatively very simple, and includes a wire which is to be made radio-active, a source of electricity capable of maintaining it at a negative potential of a few thousand volts, and, finally, an apparatus suitable for testing the acquired radio-activity, either by ionization or by photographic effects. The best form of conductor to be made radio-active is that of a wire, since the electric density on its surface is comparatively high even at low potentials. Besides, the active surface of a wire may, as Rutherford showed in the case of thorium rays, be rubbed off and so transferred to leather, and obtained in a concentrated form for photographic purposes. The material of the wire should be either copper or aluminium. The active surface of the former may be rubbed off with the aid of a little ammonia, whereas that of aluminium may be detached by simple friction. The wire should be about 0.5 mm. thick, and not shorter than 10 meters. The charged wire should be carefully insulated, as the induced activity increases with the potential to which it is charged. The charging is done by a water dropper or by an induction coil. The authors have succeeded in preparing active surfaces on leather in the manner indicated, whose activity equals that of uranium ore.—Elster and Geitel, Physikal. Zeitschr., April 15, 1902.

Auto-Decoherers.—O. Rochefort discusses self-righting coherers with a view to dispose of what he considers a fallacy. It is often stated that the difficulty of regulating auto-decoherers is due to the fact that the limits between the imperfect contact which does not yet make up a coherer, and the imperfect contact producing a coherer which requires tapping, are too close together to allow of an imperfect contact producing a self-righting coherer. The author, on the other hand, shows that every self-righting coherer may be converted into an ordinary coherer by diminishing the pressure of the filings. His experimental results do not as yet enable him to say whether the converse also holds good. The practical importance of self-righting coherers is greatly increased by their successful employment for wireless telephony. By a slight modification of the soft-iron coherer the author has succeeded in using it both for wireless telegraphy and for telephony, accordingly as to whether it was used as an ordinary coherer or as an auto-decoherer. The soft-iron tube in question is derived from Tissot's tube. Such a tube, when "cohered" by a preliminary wave-train, shows a diminution of resistance which brings it exactly into the state of a highly sensitive auto-decoherer. This way of obtaining the required pressure is easier, more constant and more certain than any mechanical means, which requires a too delicate manipulation.—O. Rochefort, Comptes Rendus, April 14, 1902.

Space Telegraphy.—Capt. Jackson communicates a number of valuable observations concerning the transmission of wireless signals at sea across intervening land. He finds that some of the waves are capable of passing through, over, and possibly round the land, though in doing so their energy is reduced to an extent depending upon the height, extent and nature of the obstruction. He describes a remarkable case of an extremely precipitous, narrow, but high promontory jutting out from the mainland, and consisting of hard rock containing iron ore. Its height was 800 feet, and signals were sent from a vessel 18 miles off to a ship cruising about the promontory. The distance at which signals could be exchanged in the open sea was 5 miles, but the promontory cut them off entirely. It cast, indeed a sharp "shadow," the signals ceasing abruptly as the receiver disappeared behind the cliff. In other cases the effect was less marked. Limestone was found to be less obstructive, and sandstone still less so. A cliff of porous coral sandstone 250 feet high and 6 miles across reduced the signaling distance from 25 to 30 miles. Weather conditions also have an important influence, especially in sub-tropical regions. In the Mediterranean, a sirocco wind, holding moisture, salt and dust in suspension, absorbs the waves to a great extent. Lightning flashes always produce signals, and sometimes spell words in the Morse code, though the usual type is that of the letters *ei* in the Morse code. As regards the relative importance of the air wire and the earth connection, the author found that the absence of earthing in the receiver reduces the signaling distance by 50 or even 70 per cent, and its absence in the transmitter reduces it by 85 per cent. But a condenser of suitable capacity acts nearly as well as a good earth. The air wire, on the other hand, is practically indispensable, as the author did not succeed in signaling over more than 2 miles without an air wire, even with good earthing.—H. B. Jackson, Proc. Roy. Soc. No. 462, July 8, 1902.

Magneto-optic Effects.—W. Voigt reviews recent discoveries of magneto-optic effects in the light of his own theory, which, it will be remembered, rests on pure "phenomenology," and does not postulate either the electron theory or its rivals. The author refers especially to the observations of Corbino, and the new effect discovered by Majorana. Corbino's effects were quite amenable to the author's theory, but were imperfectly described. Later work by Corbino and Zeeman has led him to alter his views as to the nature of the Corbino rotations. Since in Corbino's own work the phenomena are confused by the superposition of several simultaneous effects, the author requested Zeeman to investigate the case in which the sodium vapor has only a slight density, and at the same time the field has had such a strength that the components of the doublet are sharply marked off from each other and from the reversed lines of the source which lie between them. Zeeman carried out this work and communicated the results to the author for publication. He found that the negative rotation, which was as high as 500 deg. with a field of 18,000 units, decreased considerably on increasing the field to 25,000 units. This is a confirmation of the author's theory. As regards the Majorana effect, the author mentions having received a letter from the discoverer, stating that he had obtained a preparation showing the effect fifty times more intensely than the colloid iron preparation previously described. But even now the constitution of the preparations depends so much upon accidental circumstances that not only the order of magnitude, but also the sense of the double refraction varies from one preparation to another. The author points out that the double refraction described by Majorana is demanded by his theory, and has actually been shown to exist in sodium vapor, but has been looked for in vain in heavy flint glass. The peculiar behavior of solutions when the plane of polarization is inclined to the direction of the field is explained as a magnetic pleochroism which is governed by the amplified theory framed for explaining the Kerr effect and the triplets of the inverse Zeeman effect. In the language of the electron theory, the electric field modifies the quasi-elastic forces in a polar manner, whereas the magnetic field modifies the apparent mass of the electrons in a similar manner.—W. Voigt, Ann. der Physik, No. 8, 1902.

Preparation of Pure Iron.—The preparation of compact masses of pure iron is of great physical interest, and L. Houllevigne has, therefore, studied the process devised by Goldschmidt, which involves the reduction of iron oxides by means of aluminium. He recommends the employment of at least 3 kg. of substance, aluminium filings sifted, washed in petroleum essence and dried, and pure sesquioxide of iron, free from sulphur and carefully dried, in excess of about 15 per cent over the amount required for the chemical reaction, and crucibles lined with magnesia. If a lesser amount of the reagents is employed, the iron remains suspended in the shape of separate globules, in a cavernous mass surrounded by small crystals of corundum. The addition of 20 per cent of powdered cryolite to the mass increases the fusibility and raises the yield from 30 to 53 per cent. The best commercial Fe_2O_3 contains 98.2 per cent of the oxide, but the slightest trace of sulphur is very noxious. There is even greater difficulty in obtaining pure aluminium free from fatty matter. The best way is to wash the filings with petroleum essence and then dry in a sand-bath at 150 deg. for several days.—L. Houllevigne, Journ. de Phys., May, 1902.

Unipolar Currents.—C. Christiansen describes, under the above title, a peculiar departure from Ohm's law observed in certain electrolytes. We are familiar with the unipolar currents obtained when one electrode consists of aluminium, but in this case both electrodes consist of mercury, and the author applies the term unipolar to the current through mercurous nitrate in nitric acid, because it greatly depends upon the size of the cathode, and not on the size of the anode. The irregularity observed is that under certain conditions the current is independent of the E. M. F. The nitric acid alone begins to be electrolyzed at 1.7 volts. The $HgNO_3$ acts as a depolarizer, and is electrolyzed even at the smallest voltage. But after some time hydrogen also is evolved, giving a counter E. M. F. of p volts. The applied voltage being V, and the resistance r, the current is

$$u=\frac{V-p}{r}$$

Now, on increasing V, p also increases, and it appears that the difference $V-p$ remains constant up to 1.7 volts, and hence the current is independent of the E. M. F. It varies, however, directly as the surface of the cathode, and as the percentage of mercurous nitrate. The author dissolved one gramme $HgNO_3$ in 1,000 cubic cm. of normal nitric acid. The phenomenon described recalls the similar behavior of gases pointed out by Stark.—C. Christiansen, Ann. der Physik, No. 8, 1902.

* Compiled by E. E. Fournier d'Albe.

NEW METHOD OF MANIPULATING LIQUEFIED GASES IN SEALED TUBES.

By HENRI MOISSAN.*

FOR some years I have had occasion to conduct a large number of reactions by means of liquefied gases, and it may be useful to describe some precautions necessitated by such experiments.

The question of the liquefaction of gases, the study of which has been resumed in consequence of the important investigations of our colleague, M. Cailletet, has reached an industrial phase.

We can now handle with facility solid carbonic acid and liquid air. It is probable that in a short time it will be possible to operate in a range of temperatures from that of the electric furnace, 3,500 deg., to the ebullition of liquid hydrogen —225 deg.†

When, in collaboration with M. Dewar, I engaged in researches on the liquefaction of fluorine, I made use of the slow evaporation of a mixture of solid carbonic acid in ethylic alcohol to obtain a temperature of —80 deg.‡

Wishing to apply this process to the numerous manipulations of a chemical laboratory, I have sought first to ascertain what liquid would allow of dissolving solid carbonic acid in the largest quantity, and consequently of obtaining the most intense cold. I will state briefly some of the experiments.

The mixture of solid and of liquid carbonic acid was placed in a vessel with annular space freed from air, in order that the loss by radiation might be as slight as possible. To prevent the evaporation, a rapid current of air was made to pass through the mixture. This had been dried previously by its passage through two large flasks of ten liters, one containing fragments of pumice soaked with sulphuric acid, and the second containing large pieces of porous calcium chloride. By employing the air at the ordinary temperature of the laboratory, that is at about 18 deg., a constant temperature of 85 deg. was secured with ethylic and methylic alcohol.

With solid carbonic acid and methyl chloride, or with ethylic aldehyde, the temperature was lowered to 90 deg. Ethylic ether, saturated with solid carbonic acid, with which it seemed to form a combination, descended to 95 deg. Finally, acetone, which dissolves a much greater quantity of anhydride, reached a temperature of —98 deg. For this reason I give preference in the laboratory to the mixture of acetone and carbonic anhydride.

When there is occasion for a lower temperature, it can be readily obtained by cooling the dry air, facilitating the refrigerant mixture. For this purpose the air is made to pass through a first mixture of acetone and of anhydride in a metallic worm, at the temperature of —80 deg. The cold air then coming into the second mixture of acetone and anhydride in excess may lower its temperature to —110 deg.

For lower temperatures liquid air is to be employed; or better, liquid oxygen. A temperature of 182.5 deg. can thus be constantly obtained. If still lower temperatures are required, the ebullition of oxygen can be utilized, or that of liquid air under reduced pressure.

When the reaction of a liquefied gas or a solid is desired, the pressure which it gives at the ordinary temperature may be utilized, provided its critical point is sufficiently high to keep it liquid in a sealed glass tube.

The difficulty is always to seal the tube containing the liquefied gas. To accomplish it, the tube may be cooled sufficiently to cause all the liquid to pass to the solid state. Under these conditions, a vacuum can be produced in the tube containing the solidified gas by means of a mercury-blowing machine; the glass is then sealed without trouble. With some practice, and leaving a sufficient thickness of glass in the tapering part, tubes capable of resisting pressures of 200 to 300 atmospheres can be produced.

For these experiments I usually employ tubes of 10 millimeters exterior diameter, and 6 millimeters interior diameter. Ammonia, chlorine and liquid hydrogen sulphide are thus kept. If the pressure must be stronger, tubes of 7 millimeters in exterior diameter, and 3 millimeters in interior diameter, are used. In such sealed tubes, and under the same conditions, liquid acetylene and liquid iodhydric acid are kept. This method is applicable in the laboratory to the preservation of pure dry gases.

When the pressure must amount to 300 atmospheres, I employ tubes only 1.5 millimeters in interior diameter and 6 millimeters in exterior diameter.

I may cite on this subject the experiments I have made on sulphammonium on the action of iodine in presence of ammonia and on the action of liquid acetylene on the alkaline metals.

When acetylene is solidified, it readily assumes the crystalline state. On coming from the glass tube, the solid acetylene may be lighted, and it will burn with a fuliginous flame, like a piece of camphor or solid benzine.

By employing these methods in my laboratory, M. Defacqz has been able to study the action of liquid iodhydric acid on certain metallic chlorides, and M. Lebeau has been able to conduct his researches on the action of alkaline metals in presence of arseniated liquid hydrogen.

When the experiment is terminated, the study of the products of the reaction is very easy. It is sufficient to cool the tube in order to solidify all the gases in it, and to put the tapering extremity in communication with a pump or mercury-blowing apparatus. The point of the sealed glass tube is broken, and on allowing the temperature to rise slowly, the different gaseous and liquid bodies produced can be fractionated. The bodies not volatile at the ordinary temperature remain at the bottom of the tube. Before breaking the point of the cooled tube, it is well to make sure, by a preliminary test, that all the gases are solidified.

Certain precautions should always be taken in these experiments. In particular, the gases should be as pure as possible, and all trace of moisture be avoided. All the reactions in which hydrogen may be set at liberty cannot be studied by this method. The pressure in the interior of the glass tubes becomes too great, and the tubes burst. And if explosion is avoided, it is necessary to continue the cooling until the hydrogen is solidified, which at present is quite difficult.

Under these conditions, the completion of the experiments in glass becomes well nigh impossible. When a glass tube is subjected to the temperature of the ebullition of oxygen, it often breaks on returning to the ordinary temperature. This property singularly complicates experiments undertaken below —200 deg. This difficulty may be in part obviated by allowing the tubes to return very slowly to the ordinary temperature and keeping them several hours at temperatures between —110 deg. and —50 deg.

These manipulations are always dangerous, and great precaution should be observed in handling glass tubes containing gases and liquids under strong pressures.

* Memoir presented to the Académie des Sciences and translated for the SCIENTIFIC AMERICAN SUPPLEMENT.

† It will be borne in mind that the Centigrade thermometer is always used in French scientific investigations, unless otherwise specified.—Trans.

‡ This is according to the practice of Faraday and of Thilorier. It has become practicable in laboratories generally on account of the industrial preparation of liquid carbonic acid. The refrigerant mixtures described by MM. Cailletet and Colardeau in the Comptes Rendus as thus obtained reach the following figures: ethylic ether —77 deg.; methyl chloride —82 deg.; sulphurous acid —80 deg.; acetamylic ether —78 deg.; phosphorus trichloride —76 deg.; absolute alcohol —72 deg. In operating in a vacuum with methyl chloride they have reached a temperature of —100 deg.

CALCIUM CARBIDE FROM NON-ELECTRIC FURNACES.

RECENT experiments on the heat of formation of calcium carbide once more direct our attention to the use of mixtures of air and oxygen in metallurgical furnaces. The unsatisfactory condition of the carbide industry has various causes, as electric furnaces are undoubtedly wasteful, and many attempts have been made to prepare the carbide in ordinary furnaces. The experiments with peat are not likely to prove successful. But Rothmund has shown that carbide can be formed at so low a temperature as 1,620 deg. C., and he further demonstrated that at 1,560 deg. finely powdered calcium carbide is split up again into lime and carbon by carbon monoxide gas. This redecomposition of calcium carbide has often been suggested, and is, indeed, not surprising, when we consider that the oxides of the alkali metals are reduced by carbon at white heat, while at red glow a piece of sodium metal will decompose carbon monoxide gas into oxygen and sooty carbon. Rothmund's furnace consisted simply of a hollow arc-light carbon, charged with powdered lime and carbon, and heated electrically. Boochers estimates that in crucibles not heated by the electric current the formation of calcium carbide requires a temperature of at least 2,000 deg. C. He charged a graphite crucible with layers of lime and charcoal, using an excess of the latter, as the crucible was not heated from outside, but all the heat was produced within the mass by combustion with air to which more or less oxygen was added. The air mixture was preheated by passing it through a coil wound round the upper part of the crucible. If we assume that carbon monoxide would be produced from this combustion, the following temperatures should result after Le Chatelier and Mallard: Burning air, 1,260 deg. C.; air containing 35 per cent of oxygen, 1,800 deg.; air with 50 per cent of oxygen, 2,200 deg.; pure oxygen, 3,100 deg. If some carbon dioxide is formed the temperatures will be higher. No carbide was formed when air or the 35 per cent mixture were applied; with mixtures of 50 or 60 per cent of oxygen fair yields of crystallized calcium carbide were obtained. That carbide can be easily produced when we feed an ordinary furnace with oxygen is confirmed by Danneel; no preheating of the oxygen is required. Common illumination gas, on the other hand, will not answer, because its flame is too diluted. This may sound strange, but the following experiment, described by Weögenburg, explains the point. The gas is heated by electric resistances in a closed chamber, provided with a burner at the top, and mixed with a sufficient amount of oxygen to give a non-luminous flame. It will be found that only the carbon is burned to monoxide and partly to dioxide, while the hydrogen escapes uncombined; the hydrogen, therefore, only dilutes the gas. But we return to the formation of carbide in furnaces burning air, artificially enriched with oxygen. Such air can be made in various ways, and is much less expensive than anything approaching a high percentage oxygen. Linde machines, it is stated, yield 1 cubic meter of a 50 per cent oxygen, or 8 cubic meters of a 35 per cent oxygen, per horse power hour. If we feed metallurgical furnaces with such oxygen we could attain much higher temperatures than we produce at present with the aid of powerful blowing engines. We are quite aware that rich oxygen is not likely to become cheap, and that laboratory reactions of pure oxygen have not much importance for the practical metallurgist. But we might try ogygenized air.—Engineering.

ABRASIVE METALS.

ABRASIVE metals are, as a whole, but little understood, although they are in one sense among the most important of mineral products, says Dr. Joseph Hyde Pratt in "Mineral Resources of the United States," published by the United States Geological Survey.

The principal abrasives fall into three general groups: those which occur as rock formations, and are cut and manufactured directly into the form desired, while retaining their original rock structure and appearance, as grindstones, whetstones, etc.; those which occur as a constituent of either a rock or a vein, and have to be mechanically separated and cleaned, as corundum, emery and garnet; artificial abrasives, as carborundum, crushed steel and artificial corundum.

The use of abrasives is growing with the increase of our manufacturing industries. The total value of natural abrasives produced in the United States in 1901 was $1,194,572, as compared with $1,208,073 for 1900.

Corundum and emery are put upon the market in the three forms—as grains of powder, as emery paper and as wheels and blocks of various shapes and sizes. The total amount of emery and corundum produced in the United States in 1901 was 4,305 short tons, valued at $146,040, as compared with 4,305 tons, valued at $104,715, in 1900.

The imports of emery into the United States in 1901 amounted to $294,999, as compared with $239,596 in 1900.

The experiments in producing artificial abrasives that have been in progress during the last fifteen years have met with success, and there are now three artificial abrasives on the market—carborundum, crushed steel and artificial corundum. Carborundum is produced by the Carborundum Company at Niagara Falls, and in 1901 the total production of carborundum was 3,838,175 pounds, valued at from 8 to 10 cents a pound, as compared with 2,401,000 pounds in 1900. Carborundum is now used to a certain extent as a general abrasive. Crushed steel is used in the stone cutting trade, particularly by the marble and granite cutters. The production of crushed steel by the Pittsburg Crushed Steel Company in 1901 amounted to 690,000 pounds, being 10,000 pounds less than the production of 1900. A new industry has been started in the manufacture of artificial corundum. The Norton Emery Wheel Company has erected a plant at Niagara Falls for the manufacture of artificial corundum, and already two or three carloads of the material have been manufactured and made into wheels, etc., which are reported as giving good satisfaction.

At the present time garnet is obtained in four States —New York, Connecticut, Pennsylvania and North Carolina. In New York the garnet is obtained from near North Creek and Minerva, in Warren County, in the valley of the Upper Hudson River, and in Essex County. In Connecticut, garnet is found near Roxbury, Litchfield County.

Most of the garnet mined is used in the manufacture of sandpaper or "garnet paper," which is extensively employed for abrasive purposes, especially in the manufacture of boots and shoes. Practically all the garnet produced in North Carolina is manufactured into wheels, which are sold as emery wheels. The production for 1901, as reported to the Survey, is 4,444 short tons, valued at $158,100, as compared with 3,185 tons, valued at $123,475, in 1900. The average value a ton of the garnet produced in 1901 was $35.57, as compared with $38.76, the value of a ton in 1900.

Millstones are found in various localities in the United States. The New York millstone quarries are located in a belt of sandstone and conglomerate on the Shawangunk Mountains, extending across the towns of Rochester, Marbletown, Wawarsing, Gardener, New Paltz, in Ulster County, and the product is known as "Esopus" stone.

A good many buhrstones are still imported from France, Belgium and Germany, and they are considered more satisfactory than the American stones. The production of millstones in 1901 amounted to $57,179, as compared with $32,858 in 1900, and with $28,115 in 1899. The value of the imports of millstones and buhrstones in 1901 was $42,187, as compared with $28,904 in 1900.

The total value of the production of all kinds of grindstones in 1901 was $580,703, a decrease of $129,323 from the production of 1900, which was $710,026.

Grindstones continue to be imported into the United States, and they come from Newcastle-on-Tyne, in England; from Edinburgh, Scotland, and from Bavaria. The imports in 1901 amounted to $88,871, as compared with $92,581 in 1900.

The total export of grindstones from this country is now greater than the import.

NEW COMPOUND OF VANADIUM BY ELECTRIC FURNACES.

A NEW compound of vanadium is the subject of a paper lately presented to the Académie des Sciences by Messrs. Moissan and Holt. With the exception of vanadic acid and the vanadates, the compounds of this metal have been but little studied up to the present. M. Moissan has already formed the carbide of vanadium in the electric furnace. It is a stable and very hard body, easily attacked by nitric acid. The silicide of vanadium is the subject of the present paper. The experimenters start with the oxide of the metal V_2O_3, which is obtained by reducing vanadic acid at a red heat in a current of pure and dry hydrogen. The silicide is formed by two methods. In the first the vanadic oxide is heated in the electric furnace with five times its weight of silicon, when the mass melts and the reaction takes place as follows:

$$2\,V_2O_3 + 11\,Si = 4\,VSi_2 + 3\,SiO_2.$$

A current of 1,000 amperes and 50 volts is used, with about 2 minutes heat, and in this case the only compound of vanadium produced is the silicide, VSi_2, in the crystalline state. The mass is treated with a 10 per cent potash solution and the crystalline deposit is washed and purified. A second method of obtaining the compound is by reducing a mixture of silicon and vanadic anhydride by powdered magnesium, according to the method of igniting-powdered metals which has been lately discovered by Dr. Goldschmidt. With 10 grammes of vanadic anhydride and an equal weight of silicon is mixed 5.5 grammes of powdered magnesium. The mixture is ignited and the reaction spreads rapidly throughout the mass. When completed a mass of the silicide is found at the bottom, having been perfectly melted; it is treated with nitric acid to separate the crystals. The silicide of vanadium has the form of brilliant prismatic crystals of a metallic aspect. Their density is 4.42 and they will scratch glass. They may be fused and volatilized in the electric furnace. This body possesses great stability; it is insoluble in water, ether, benzine, alcohol, etc. It seems only to be dissolved by silicon in fusion, in the midst of which it crystallizes when cold, or by melted silicide of copper. It is not acted upon by caustic alkalies, and the acids, nitric and hydrofluoric acid, or aqua regia will not dissolve it, but hydrofluoric acid, even cold and dilute, attacks it rapidly. Fluorine does not react upon it at ordinary temperatures, but at a red heat it burns in the gas with incandescence, and gives a greenish-brown residue. When heated in chlorine the action takes place without incandescence, giving a dark brown liquid which solidifies when cooled to —28 deg. C. to a red crystalline mass. This liquid is immediately decomposed by

water. Bromine has an analogous action and yields a black amorphous body, V Br_2. When heated in iodine vapor it is only superficially attacked. Hydrogen, oxygen and sulphur have but little effect upon it at a red heat. When the silicide is heated in a current of gaseous hydrochloric acid it is decomposed and burns; the result is a colorless liquid, silichloroform, which boils at +32 deg. C., besides a greenish sublimate V Cl_2 and a brownish-red residue which is very deliquescent and soluble in water V Cl_3. The metals in fusion react upon the silicide; for instance, melted copper decomposes completely a small quantity of the body and gives a silicide of copper and an alloy of copper and vanadium.

SOME USES OF ELECTRICAL PUMPING MACHINERY.

Economy in operation and maintenance is the first and most vital consideration in pumping machinery. In this respect the electrical system presents many important advantages. It is economical in the transmission of power, whereby it is possible to situate a public installation at a considerable distance from the source of power, where the enormous initial cost and maintenance expense of any other system would be prohibitive. The economy in space required is also worthy of consideration. The driving mechanism of a modern electric pumping outfit occupies but little room compared with that of a steam plant, and the space needed for wiring is infinitesimal compared with that required for piping. In case of accident, any injury to the wires can be quickly and easily repaired. There is no large loss by condensation in steam pipes or by leakage in pipes conveying compressed air. The only loss sustained with the electric system in the transmission of power is the loss due to line resistance, increasing directly with the amount of water pumped, and ceasing entirely when the pump is not in operation. When no water is being pumped, practically no electrical energy is being used; and when the pump is in operation energy is supplied in just the right amount to do the work effectively. Indeed, the regulation of the amount of power required by an electric plant is inherent in the electric motor, and varies almost directly with the amount of water pumped.

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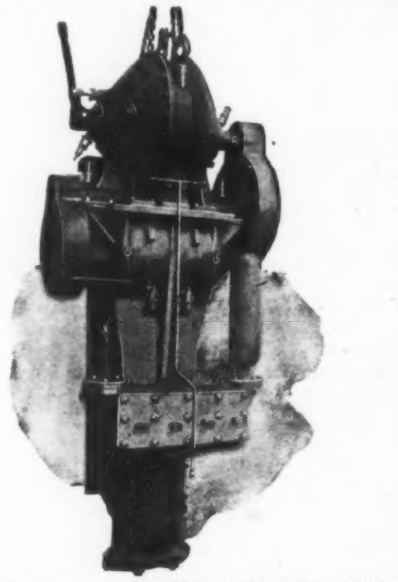

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For general mining use, where an entirely portable pumping outfit is desired, the electric mining track pump, consisting of a pump of a horizontal type mounted with a motor on a strongly constructed truck, is widely used. Such an arrangement can be hauled to any point in the mine and there operated from some convenient circuit.

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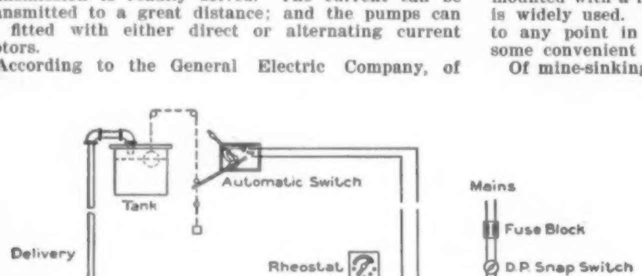
By Frank C. Perkins.

In installing a modern electric power generating plant for the Ougree-Marihaye Blast Furnace Iron Works in Belgium, after careful investigation it was decided that the most economical power equipment would be to utilize the waste gases from the blast furnaces at a central power plant and transmit the



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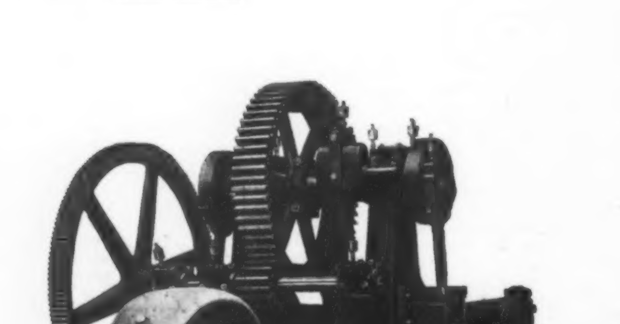

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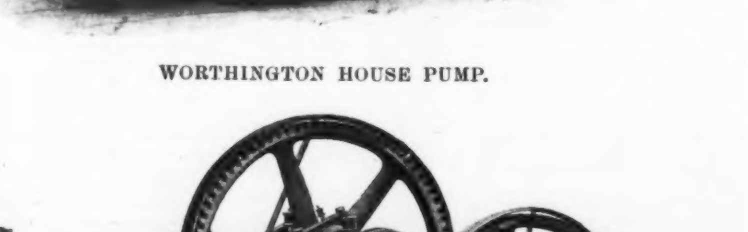

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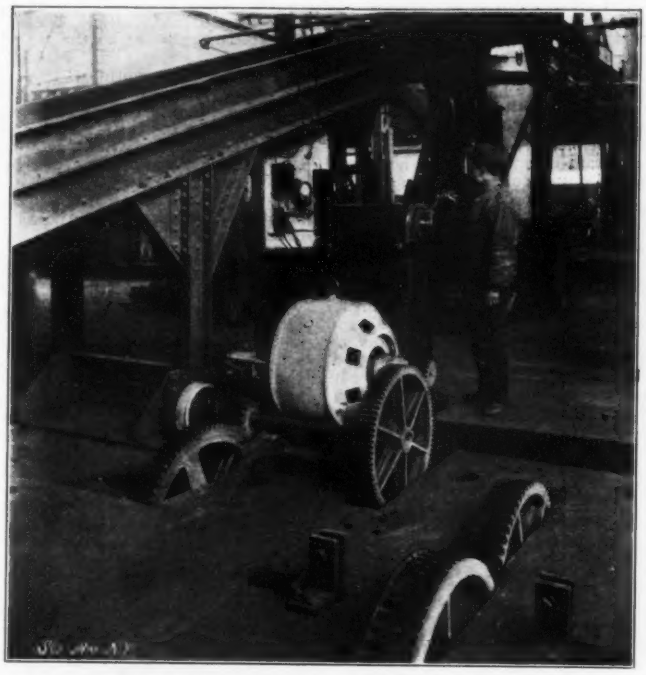
energy electrically to the power-consuming centers, which are about three-quarters of a mile away.

It was further decided to utilize direct-current machinery for this plant on account of numerous motors already in operation about the plant using continuous currents of 225, 125 and 65 volts potential; and also on account of the difficulty of operating polyphase alternating current apparatus in parallel when driven from gas engines. Near the blast furnaces the central power station was located and supplied with three units, one of 150 horse power capacity and the other two of 600 horse power each. These large units consist of 600 horse power horizontal gas engines of the Delmarre-Debouteville blast furnace type, constructed by Cockerill of Seraing, and direct-connected to multipolar direct-current generators built by the Compagnie Internationale d'Electricite of Liege, Belgium.

The electric method of spark ignition is employed in the gas ignition chamber; and in order to avoid electric contacts becoming fouled by dirt, and prevent deposits of dirt in the cylinder and a sticky piston, the gases are blown across a special cleansing apparatus which also cools them and increases the density.

The twelve-pole direct-current 500-volt dynamos are shunt wound and the dynamo shaft is provided with a half coupling which fits to a similar half coupling on the gas engine shaft. The armature of the generator is drum wound, and the coils are shaped in formers and fitted into a core built of sheet steel stampings, evenly insulated with paper, and arranged to insure perfect insulation and ventilation.



ELECTRIC LOCOMOTIVE FOR DRIVING LIVE ROLLERS.

This great steel plant has had a wonderful growth, and although at first operating with but a few men and a few puddling furnaces and rolling mills, it now gives employment to 5,500 men and consists of vast rolling mils, one of which is operated by a 10,000 horse power reversible engine; as well as numerous steel works, brass foundries, and a plant for making cement from the slag of the blast furnaces as well as utilizing the basic slag for the manufacture of a rich phosphoric manure.

The third smaller unit in the power house can be operated in parallel with the larger units, but is used mainly to supply power at times when only a few motors are running, as on holidays. The plant will ultimately utilize 3,000 horse power, and provision was made for this amount of electrical energy in providing space for the equipment.

The generating units are of 550 volts potential and are connected in parallel to two copper bus bars on the main switchboard, and from these bars the current is conducted to the receiving station over aluminium conductors, the receiving station being located in a central position at the works near to the principal consuming centers.

At the receiving station the switchboard is arranged for a five-wire distribution, and on account of limited floor space the building is constructed at a height of about 20 feet above the ground and is supported by six iron columns, the structure being entirely of steel, and thus fireproof. In order to have two circuits of 250 volts each a balancer and neutral bar is employed. Each of the two circuits of 250 volts has a balancer which gives two circuits of 125 volts each, and in this way the old direct-current motors of low voltage are supplied with current.

The new motors installed are of 500 volts, and the 250-volt motors are distributed evenly over the two 250-volt circuits, and the balancer is said to maintain a constant pressure even when the load variation between the two sides reaches as much as 100 horse power.

Not only the small motors, but also the incandescent lamps and arc lamps are supplied from the four circuits of 125 volts; and the possibility of having the several voltages 125, 250 and 500 at hand is most convenient for utilizing multispeed motors with varying pressure.

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The main bearings are cooled by a stream of cold water as well as the piston, exhaust valve and cylinder and all other parts liable to get hot from the gas ignition; while a special regulating device is employed which stops the engine immediately in case the supply of water is cut off from any cause whatever, and all danger from overheating is thus avoided entirely.

A very high permeability magnet steel is used for the fields, the poles being cast in one piece with the yoke; while the pole pieces are laminated and bolted on, the horns being so designed as to give sparkless commutation with fixed position of brushes as variable loads.

There are in operation at the works nearly seventy motors varying in capacity from ½ horse power to nearly 100 horse power, and larger ones are to be installed as the plant is increased in size to full capacity.

There are nearly a dozen electrically-operated overhead traveling cranes in various points in the works, three of which are operated by four electric motors; five of the cranes have three motors each, and two are operated by single motors. The latter single-motor cranes are of two tons capacity and are used for manipulating loads of sheet iron, and are instances of the first application of electric power to hoisting engines.

One of the three-motor cranes, lifting 5 tons, is used in the Siemens-Martin steel foundry, and two of the three-motor cranes, with a capacity of 4 tons each, are high speed, hoisting at 55 feet per minute, and the cross-travel speed being 250 feet per minute. The motors for these cranes are wound for 250 volts. For use at the casting pits it is very important that the crane service should be very reliable and comparatively high speed in operation. The fifth three-motor crane is a 30-ton traveler and is constructed especially to work in a space shaped like a segment of a circle; and with this design of crane this troublesome space is used as a store for extra rollers from the rolling mills. The International Engineering Company, of Liege, Belgium, has recently constructed a new electrically-driven three-motor crane of 5 tons capacity which will be utilized at the blast furnaces.

The large 22-ton cranes, which are electrically driven by four motors, are of new design and have given excellent results, using two motors for the separate lifting. The largest rolling mills, which are driven by the 10,000 horse power engine, are supplied with two of these cranes, and by their use the manipulation of the heavy masses of steel has been greatly simplified; while the cranes also greatly facilitate the rapid mounting and dismounting of the rolling mill rollers. When it is desired to handle more than 22 tons the two large hooks of the two cranes are coupled and perfect regularity of operation is insured, as the lifting speeds of the two cranes are the same. Small hooks are also provided on these cranes which have speeds five times as great as the large hooks, and these are used for handling ingots and small loads under two tons.

At the Siemens-Martin steel foundry the main hoist or winch operated electrically has a capacity of 30 tons; and there are also six electric winches or capstans for small loads fitted in the various parts of the works. Passing from the electrically-driven cranes at this plant, it may be of interest to mention that an inclined elevator is provided for lifting mineral, coke, etc., for the blast furnaces after its delivery from the canal and railway; and this inclined elevator is driven by an electric motor and lifts 10 tons a distance of about 35 feet.

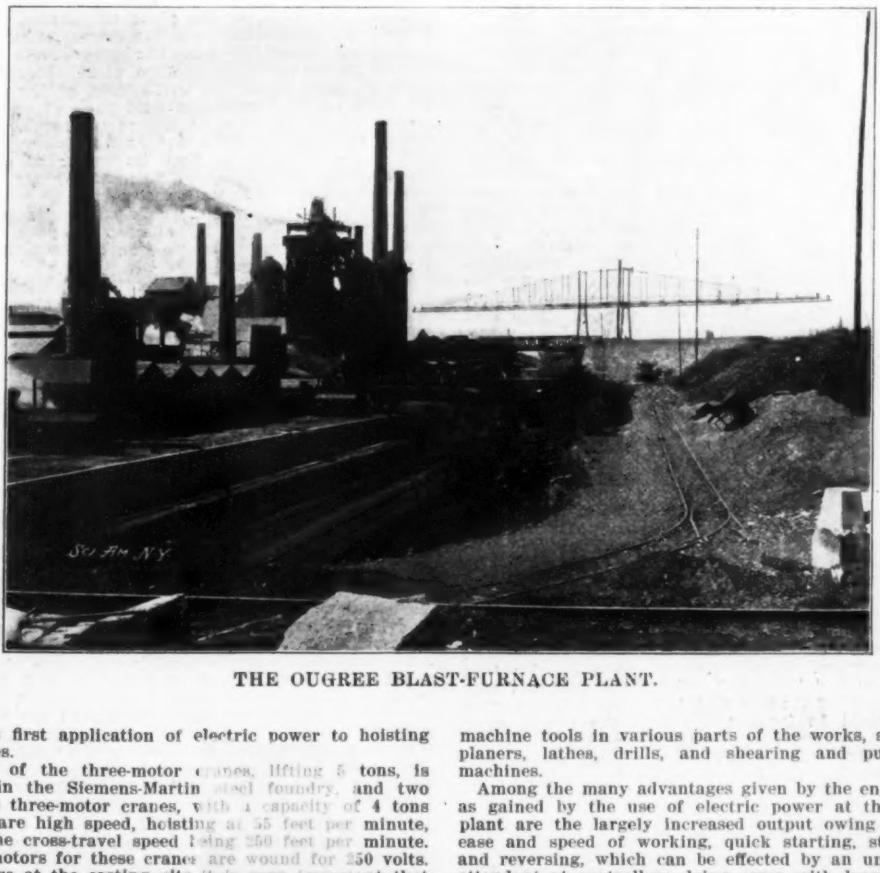
In the main rolling or cogging mill the principal rolls are, of course, driven by the power from the 10,000 horse power engine above referred to, but electric motors are extensively used for driving a large number of secondary rolls, and all of the smaller steam engines which were formerly used have been dispensed with. There are also a large number of reversible electric motors employed for driving the live rolls for facilitating the passage of the heavy steel bars backward and forward.

Electric motors are also now being employed for driving sets of drag chains. The rails or beams after being rolled to shape and cut to the proper length by circular saws are carried along by endless chain drags, and these chains are run in sets of three and are provided at intervals with blades which move along horizontally at a short distance above the ground, thus sweeping along the rails and beams.

A 40 horse power motor is employed for driving a special machine for removing the blocks from one set of rolling mills to the others, as when the rough-rolled ingots come from the large rolling mills they are cut into ingots or billets and carried while still hot to the secondary rolling mills. The electrically-operated machine raises the blocks to a certain height, when they are allowed to slide by their own weight down an inclined plane to the various finishing rolls.

The total number of arc lamps employed is about 240, each of which takes from 8 to 10 amperes, and they are connected three in series across the 125-volt circuits, and also at distant parts of the works in series of 5 or 6 lamps on the 250-volt mains. It is said that the several circuits of various pressures tend in this way to reduce the first cost of installation to a minimum. There are also used about the works more than 400 incandescent lamps of 16 candle power each, as well as numerous electric motors for driving machine tools in various parts of the works, such as planers, lathes, drills, and shearing and punching machines.

Among the many advantages given by the engineers as gained by the use of electric power at the steel plant are the largely increased output owing to the ease and speed of working, quick starting, stopping and reversing, which can be effected by an unskilled attendant at controller; doing away with large num-



THE OUGREE BLAST-FURNACE PLANT.

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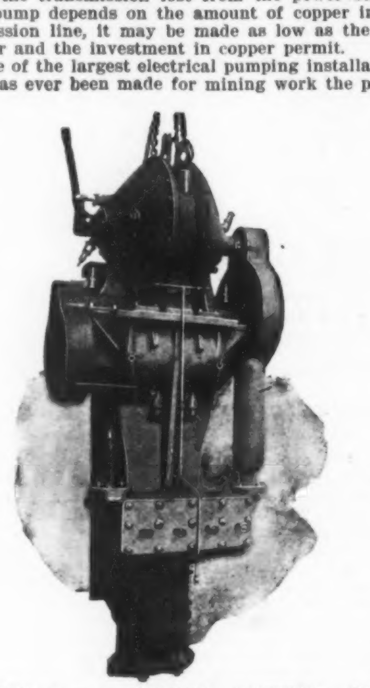

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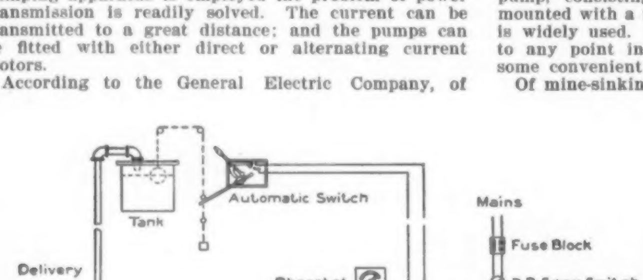

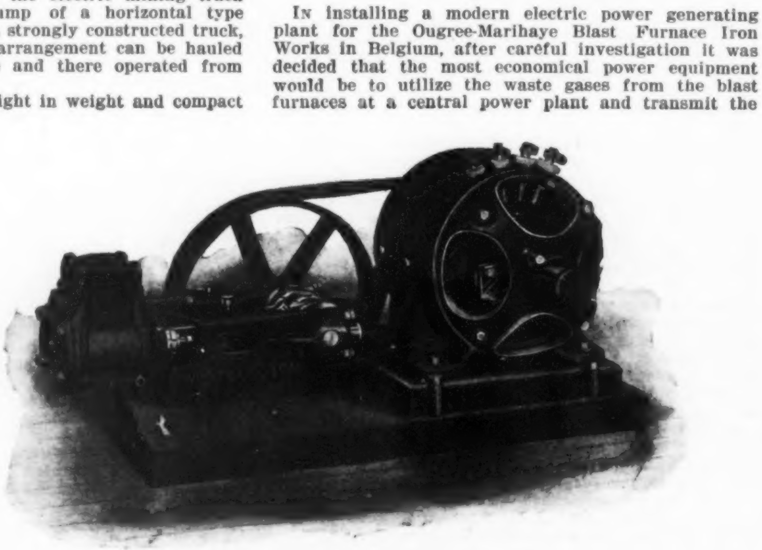

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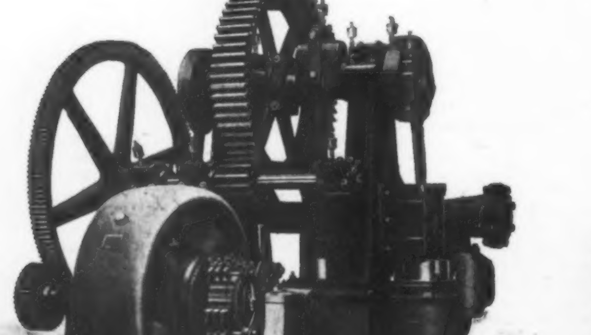

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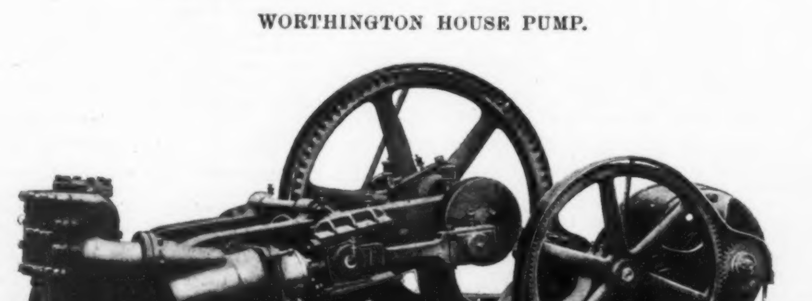

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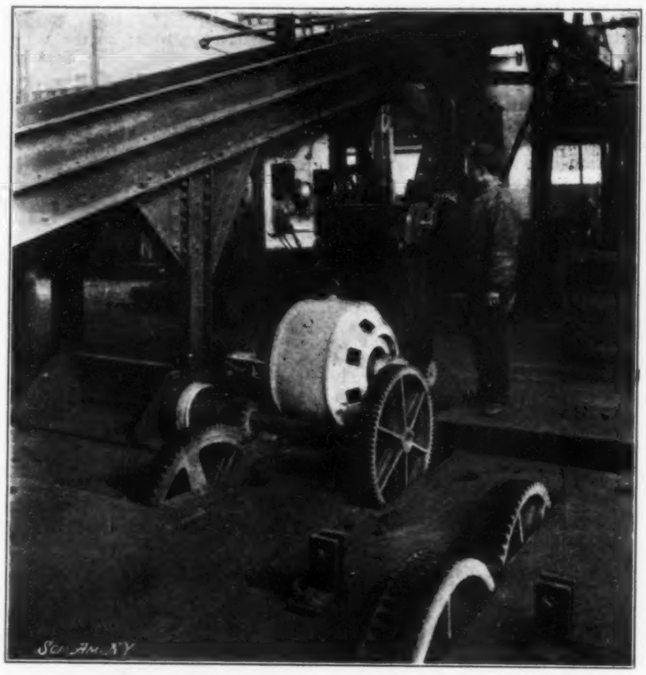
The 600 horse power blast furnace gas engine sets at central power station operate at 90 revolutions per minute, and it is said that these are the largest single-cylinder blast-furnace engines which have yet been built, while this plant is one of the first in which the waste blast-furnace gas has been made use of for supplying electric power for operating steel works. The crankshaft is supported by two main bearings, by means of tie beams; a third bearing is also supplied to support the flywheel end of the shaft, and the cranks are balanced.

The main bearings are cooled by a stream of cold water as well as the piston, exhaust valve and cylinder and all other parts liable to get hot from the gas ignition; while a special regulating device is employed which stops the engine immediately in case the supply of water is cut off from any cause whatever, and all danger from overheating is thus avoided entirely.

The electric method of spark ignition is employed in the gas ignition chamber; and in order to avoid electric contacts becoming fouled by dirt, and prevent deposits of dirt in the cylinder and a sticky piston, the gases are blown across a special cleansing apparatus which also cools them and increases the density.

The twelve-pole direct-current 500-volt dynamos are shunt wound and the dynamo shaft is provided with a half coupling which fits to a similar half coupling on the gas engine shaft. The armature of the generator is drum wound, and the coils are shaped in formers and fitted into a core built of sheet steel stampings, evenly insulated with paper, and arranged to insure perfect insulation and ventilation.



ELECTRIC LOCOMOTIVE FOR DRIVING LIVE ROLLERS.

A very high permeability magnet steel is used for the fields, the poles being cast in one piece with the yoke; while the pole pieces are laminated and bolted on, the horns being so designed as to give sparkless commutation with fixed position of brushes as variable loads.

There are in operation at the works nearly seventy motors varying in capacity from ½ horse power to nearly 100 horse power, and larger ones are to be installed as the plant is increased in size to full capacity.

There are nearly a dozen electrically-operated overhead traveling cranes in various points in the works, three of which are operated by four electric motors; five of the cranes have three motors each, and two are operated by single motors. The latter single-motor cranes are of two tons capacity and are used for manipulating loads of sheet iron, and are instances of the first application of electric power to hoisting engines.

One of the three-motor cranes, lifting 5 tons, is used in the Siemens-Martin steel foundry, and two of the three-motor cranes, with a capacity of 4 tons each, are high speed, hoisting at 55 feet per minute, and the cross-travel speed being 250 feet per minute. The motors for these cranes are wound for 250 volts. For use at the casting pits it is very important that the crane service should be very reliable and comparatively high speed in operation. The fifth three-motor crane is a 30-ton traveler and is constructed especially to work in a space shaped like a segment of a circle; and with this design of crane this troublesome space is used as a store for extra rollers from the rolling mills. The International Engineering Company, of Liege, Belgium, has recently constructed a new electrically-driven three-motor crane of 5 tons capacity which will be utilized at the blast furnaces.

The large 22-ton cranes, which are electrically driven by four motors, are of new design and have given excellent results, using two motors for the separate lifting. The largest rolling mills, which are driven by the 10,000 horse power engine, are supplied with two of these cranes, and by their use the manipulation of the heavy masses of steel has been greatly simplified; while the cranes also greatly facilitate the rapid mounting and dismounting of the rolling mill rollers. When it is desired to handle more than 22 tons the two large hooks of the two cranes are coupled and perfect regularity of operation is insured, as the lifting speeds of the two cranes are the same. Small hooks are also provided on these cranes which have speeds five times as great as the large hooks, and these are used for handling ingots and small loads under two tons.

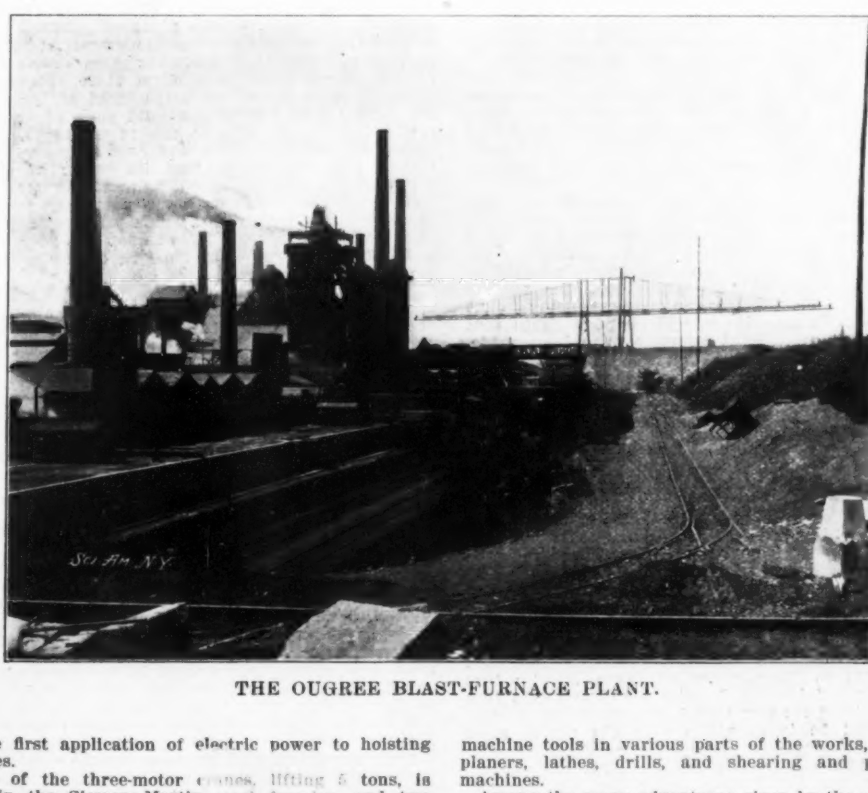
At the Siemens-Martin steel foundry the main hoist or winch operated electrically has a capacity of 30 tons; and there are also six electric winches or capstans for small loads fitted in the various parts of the works. Passing from the electrically-driven cranes at this plant, it may be of interest to mention that an inclined elevator is provided for lifting mineral, coke, etc., for the blast furnaces after its delivery from the canal and railway; and this inclined elevator is driven by an electric motor and lifts 10 tons a distance of about 35 feet.

In the main rolling or cogging mill the principal rolls are, of course, driven by the power from the 10,000 horse power engine above referred to, but electric motors are extensively used for driving a large number of secondary rolls, and all of the smaller steam engines which were formerly used have been dispensed with. There are also a large number of reversible electric motors employed for driving the live rolls for facilitating the passage of the heavy steel bars backward and forward.

Electric motors are also now being employed for driving sets of drag chains. The rails or beams after being rolled to shape and cut to the proper length by circular saws are carried along by endless chain drags, and these chains are run in sets of three and are provided at intervals with blades which move along horizontally at a short distance above the ground, thus sweeping along the rails and beams.

A 40 horse power motor is employed for driving a special machine for removing the blocks from one set of rolling mills to the others, as when the rough-rolled ingots come from the large rolling mills they are cut into ingots or billets and carried while still hot to the secondary rolling mills. The electrically-operated machine raises the blocks to a certain height, when they are allowed to slide by their own weight down an inclined plane to the various finishing rolls.

The total number of arc lamps employed is about 240, each of which takes from 8 to 10 amperes, and they are connected three in series across the 125-volt circuits, and also at distant parts of the works in series of 5 or 6 lamps on the 250-volt mains. It is said that the several circuits of various pressures tend in this way to reduce the first cost of installation to a minimum. There are also used about the works more than 400 incandescent lamps of 16 candle power each, as well as numerous electric motors for driving machine tools in various parts of the works, such as planers, lathes, drills, and shearing and punching machines.



THE OUGREE BLAST-FURNACE PLANT.

Among the many advantages given by the engineers as gained by the use of electric power at the steel plant are the largely increased output owing to the ease and speed of working, quick starting, stopping and reversing, which can be effected by an unskilled attendant at controller; doing away with large num-

ber of attendants required to look after various engines, boilers, line shafting, etc., displaced; saving in fuel from use of blast furnace gases for driving engines and generator sets at power station; dispensing with large numbers of engines, boilers, piping, etc., of low economy. By the introduction of electricity a large amount of hydraulic and compressed air machinery is displaced, and this class of machinery reduced to a minimum, while the moving of heavy masses of hot metal by electric appliances dispenses with much hand labor and the work is carried out far more expeditiously.

The utilization of the waste gases from the blast furnaces alone is of vast importance, and will lead to far more important results in the future, as the principal steel and iron plants all over the world are rapidly changing to electrically-operated tools and the use of the gas engine is increasing enormously.

It is said that in the production of 100 tons of pig iron 2,000 horse power of energy can be obtained by using the waste gases in large engines, and for electrical power transmission purposes 30,000 horse power or more could be obtained from the Liege district alone.

A technical commission under the direction of H. Hubert, engineering director of mines and professor at the University of Liege, carried out a series of tests on a powerful blast-furnace gas engine of 200 horse power which has been operating since 1898 at the Cockerill Works, Seraing. The current generated by the dynamo driven by this engine was used for operating motors, and the test lasted several days and established the best working conditions and admissible overload for the engine. The test showed the consumption of gas when engine was running at full load to be 3,113 cubic millimeters per horse power hour, the coke used having a calorific value of 997 calories.

It was found by the test, taking into account the respective efficiencies and output of engine and generator, that a comparison of the power developed by the explosion of gas in the cylinder with the power available at the terminals of the dynamo gives an actual heat efficiency of 21 per cent for the combination; while the best modern steam engines seldom show more than 10 per cent of the calorific power of the fuel burnt in the boiler furnace.

At the Ougree Blast Furnaces the electrical locomotives are especially useful, as the furnaces are nearly 1,300 yards from the steel furnaces, which are in turn a considerable distance from the rolling mills. It is well known that it is highly important that the metal should not be allowed to cool down when once heated until it has passed from the finishing rolls a completed bar or rail. One of the electric locomotives used at this iron and steel works is used for hauling the 20-ton steel ladle to and from the Siemens-Martin furnace, and is fitted with a 37 horse power motor which has a speed of travel of 190 feet per minute. The following method is employed for supplying the necessary current to the locomotive, instead of a slot conduit, third-rail or trolley, which cannot be used on account of the close proximity to the steel furnaces and the little headroom which is available. A double-insulated cable serves to convey the current from the mains to the locomotive. This is done by means of a drum, around which the flexible cable is coiled as the locomotive travels. There are two brushes, which press on gun-metal rings which are connected to the end of the cable attached to the drum. A counterweight prevents the cable dragging along the floor. The accompanying illustrations show the electrically-equipped apparatus at this important industrial plant.

FOUCAULT'S PENDULUM AT THE PANTHEON.

In its sitting of the 8th of January the Astronomical Society of France requested its general secretary, M. Camille Flammarion, to make arrangements with the authorities of the Society of Fine Arts for installing the pendulum of Léon Foucault at the Pantheon, where it was suspended during a part of the year 1851. The experiments of the celebrated academician were perfectly successful with reference to the popular demonstration. A large number of spectators came to see the earth revolve, but from a scientific view-point the experiments were incomplete. Indeed, the author died without leaving a full account of his experiments. In operating with a pendulum 67 meters in length scientists meet with a crowd of difficulties, which it will be quite instructive to study with the aid of the present perfected methods of observation. This appears from the article which Foucault himself published in the Journal des Débats on the 31st of May, 1851, which is the most complete account we have of his magnificent undertaking. Since that time a large number of attempts have been made, notably at Rio de Janeiro, on the initiative of the Emperor Dom Pedro II.; on the tower of Saint Jacques; on the Eiffel Tower and at the Conservatory of Arts and Trades, where the pendulum of Foucault is constantly at work. But the two most striking experiments are those which took place in the Cathedral of Reims and in the Cathedral of Amiens; the first by M. Dubois, professor of astronomy, and the second by Maumenée, the celebrated chemist and physicist, who died a few years ago. The architecture of these venerable edifices harmonizes perfectly with the oscillations of a giant pendulum. In consequence of a regrettable error, it was supposed by some that scientific demonstrations and researches were contrary to the canonical regulations and could not take place within edifices devoted to worship. At the time of the oscillations in the Cathedral at Amiens the bishop delivered an eloquent sermon to protest against such an imputation. Was it not in pagan temples that astronomy had its birth? Who would maintain that the worship of the true God, less favored than that of idols, could be incompatible with the search after truth?

The Revue Chronométrique continues the subject.

Newton was the first to notice the possibility of causing the diurnal movement of the terrestrial globe to be made apparent by experiment. If the earth revolves all the points of its surface, he reasoned, are animated with an angular velocity, which increases with the distance from the ideal axis of rotation, and consequently ceases at the poles, and is maximum at the equator.

As a consequence of this conception of the movement of the earth the summit of any edifice moves from west to east with more rapidity than its base. Hence it follows that if a ball of lead is allowed to fall from the top of a tower, this body, preserving its initial velocity during the fall, should strike the ground a little to the east of the foot of the vertical passing through the point where it is left to itself.

Experiments confirm this ideal of movement, and the scientist Benzenberg, who repeated them at the commencement of the nineteenth century in the interior of a church tower and of a mining shaft, could measure the deviations with precision, notwithstanding the restricted height for the fall of the bodies.

Later, Léon Foucault had recourse to the pendulum to demonstrate, in a striking and impressive way, the rotation of the earth. He was inspired by the law of the independence of simultaneous movements brought to view by Galileo, and which may be enunciated thus: The movement common to several bodies does not control their individual movements.

In support of this principle, which experiment alone can verify, the regular rate of watches may be cited, notwithstanding the varied movements to which they are subjected; the regular rate of clocks, whatever their orientation. If the movement of the earth influences the pendulum, a clock adjusted in the plane N—S would cease to indicate the exact time in the plane E—W.

The experiment which especially served as the base for Foucault's demonstration of the diurnal movement of the earth was the following: A plumb line is suspended to a potence, whose foot rests on a horizontal platform capable of taking a movement of rotation around its center; the plumb line is removed from the vertical and an observation taken, with reference to a fixed point of the orientation of the plane in which the pendulum moves; then a circular movement is impressed on the platform by means of a crank carrying a pinion, which engages with a toothed wheel placed in the circumference of the platform. Whatever may be the velocity of rotation, the invariability of the plane of oscillation of the pendulum is made manifest.

Suppose now a pendulum suspended above the pole in the prolongation of the terrestrial axis; remove it from its perpendicular position without giving it a lateral impulse and leave it to the action of its weight; the mass of the pendulum will oscillate, describing the arc of a circle in a well-determined plane, invariable in direction.

Admit that this direction passes through the center of the sun. If the earth is fixed and the sun movable, the pendulum will keep the same position with respect to terrestrial objects, and the sun will move from the plane of oscillation. If, on the contrary, the sun is fixed and the earth movable, the pendulum, preserving its direction invariable in space, by virtue of the inertia inherent in its mass, will continue to move in the plane of the sun and be displaced with reference to terrestrial objects.

The observer, participating in the movement of the globe, will, without consciousness, refer his displacement to the pendulum, in such a way that the plane of oscillation will appear to turn around the vertical of the point of attachment with the same velocity as the earth (15 deg. per hour), but from east to west; that is to say, in the direction of the apparent movement of the heavens. Such are the conditions in which the rotation of the terrestrial axis, with reference to the sun, would be visible at the poles.

Foucault endeavored to ascertain what action the distance of any point of the globe relatively to one of the two poles exercises on the plane of the pendulum. By calculation he found that at the equator the apparent movement of the plane of rotation ceases, because it is perpendicular to the terrestrial axis, and consequently that it becomes the more visible as the pole is approached. To confirm these theoretic results, Foucault caused to be fastened at the top of the vault of the Pantheon a solid piece of metal for supporting a steel wire 64 meters in length, at the lower extremity of which was fixed a heavy sphere, turned and polished so that its center of gravity was made to coincide exactly with the center of the object. This sphere at its lowest part had an appendage terminated by a point, which furrowed a passage in a layer of fine sand spread upon the floor. After each oscillation, the retrogradation of the oscillating plane could be observed.

At Paris, whose latitude is 48 deg. 50 min., the deviation of the pendulum is 11 deg. 17 min. 33 sec. per siderial hour, and 31 hours 48 minutes are necessary for an entire revolution of the oscillating plane.

Nothing could depict the surprise which the observer experiences in following the slow oscillation of such a majestic pendulum. He notices that his position is displaced continuously with the edifice in which the pendulum is suspended, and receives from this observation a profound and durable impression.

PROGRESS OF THE YEAR IN ASTRONOMY.*

The most prominent astronomical feature of the year has been the new star of Perseus. Of all the Novæ which have appeared up to the present, it is perhaps this one which has presented the most novel and interesting features, and yet it cannot be said that the mystery is cleared up. The circumstances which have lately been brought to light are so astonishing and unforeseen that they only make it, so to speak, still more mysterious. As to what is the cause of these catastrophes, so grandiose and sudden, and lasting so short a time, we are reduced to hypotheses. Some astronomers think that these phenomena are due to a shock between two enormous masses, moving with a great speed; the heat produced by the shock would explain the sudden appearing of the light. They remark that the new stars become thus brilliant in the Milky Way, that is, in the region where there are the most stars, and hence a greater chance of collision. Others suppose that the sudden brilliancy of the temporary stars must be due to eruptions analogous to those which produce the solar protuberances, but incomparably more intense; in fact, the spectra, at certain periods of the transition, show the brilliant rays which are characteristic of these protuberances. Others again combine the two explanations; they admit the eruptions, but attribute them to a shock, either that an obscure body brought about the phenomena by penetrating into a sun, or that it passed only in the neighborhood and that its attraction produced gigantic tidal waves. The question still remains unsolved, and none of these theories has definitely triumphed. The alternations in the brilliancy of the new star will be remembered. On February 20, 1901, it was not even of the twelfth magnitude, but on the 23d it exceeded the first magnitude; on the 1st of March it fell to the second magnitude, and during the second half of March and the month of April it oscillated between the fourth and sixth. These oscillations were strikingly periodic in character and were continued during the following months, superposed upon the slow and continued diminution which has followed up to the present. The spectrum of the star has passed by a series of phases; at first it recalled that of the stars of Orion, with numerous black bands, but shortly after the point of maximum brightness, a series of brilliant bands appeared. The contrast between the bright and dark bands went on increasing, and the bands became extremely wide. Last, as in all the preceding Novæ, appeared the lines which are characteristic of nebulæ. We may ask whether we have witnessed, not the transformation of a nebula into a star, as would seem natural, but the inverse transformation of a star into a nebula.

Two explanations may be given for the broadening and the displacement of the bands. All may be explained by the movements of the incandescent mass, either in the case of two bodies, one obscure and the other brilliant, moving in opposite directions, or by the mass itself being possessed of a gigantic vortex movement. The hypothesis of two moving bodies, which may have answered in former cases, will hardly suffice here, where the structure of the lines is more complex and presents several maxima, thus supposing the presence of more than two layers possessed of different movements. In all cases these velocities would be enormous, and reach several thousand miles per second. At first sight the imagination refuses to admit that matter can reach such extraordinary speeds, and it rejects such an explanation. Another idea is that the bands are enlarged and displaced not by the movements of matter, but by the enormous pressures which it undergoes. This explanation was in favor for a while, as it was new, and did not require such a stretch of imagination. In fact, the question is not yet decided. But observers were not long in revealing a still more striking circumstance. A discussion was held before the Society as regards a certain nebulous appearance which was remarked about the stars' disk on a photograph obtained at M. Flammarion's laboratory. The nebulosity was not a real one, as it was due to the light of the star and could be explained by optical laws; however, the attention of astronomers was excited and soon there were discovered in the neighborhood of the star several nebulæ which this time proved real. Subsequent observation proved that these nebulæ moved away from the star with a speed of about 11 minutes of arc per year; this is about 100 times the highest of the proper motions known up to the present. To find the corresponding linear speed, we must know the distance of the star. Measurements of the parallax have given negative results. It is therefore certain that the parallax is below 1-10th second and probably does not exceed 1-100th. That is, the nebulæ move certainly at a higher rate than 18,000 miles a second and probably travel nearly as fast as light. What is it, then, that is displaced at such a great speed? Can it be matter? What can we think, then, of the power of an explosion which can send out projectiles rivaling the speed of light waves. The velocities which were before shown by the spectroscope, and which seemed so great that we hesitated to admit them, are still 100 times too small; no doubt they were only those of the heavier and less rapid projectiles. If not matter, this must be a form of radiation, of whatever nature. It is possible that they may be cathode rays, but as these are not very well known, it may be too easy to explain phenomena in this way.

The explanation of M. Kapetyn is the most ingenious and perhaps the most probable of all. The nebulæ existed previously; the light coming from the star at its brightest period illuminates successively the different parts, and thus the visible portions seem to be displaced with speed of light. Another interpretation was proposed later. The bands of the spectra show, as was observed, a very complex structure, as if the light, before reaching us, had traversed a series of absorbent layers having different speeds. It was supposed that these layers formed a series of concentric spheres, proceeding from the central star and enveloping each other mutually. As they recede from the star, their speed diminishes owing to the attraction of the central mass, like a stone thrown from the earth. Observations of these different speeds give us data as to the mass of the star, and it is found that the mass is 1100 times that of the sun. To form an idea of the full scope of these results, it must be remembered that most of the stars seem to have masses comparable to that of the sun, and even Sirius, which is much more brilliant, is only two or three times as heavy. We might ask if the accident which has just occurred in this far-off world could not happen to us at any time. What would become of us if our sun, by a sudden caprice, became in 24 hours 10,000 times as hot? But if, as the above author thinks, it is too small to be capable of such effects, we may be reassured. In sum, new problems have been proposed, and the old ones are not as yet solved and probably will not be before the star is extinguished. Such phenomena show what a variety of riches the stellar world contains, and that the multitude of brilliant points do not represent a monotonous infinity of systems all on the same plan.

In the early part of the present year the Observatories of Paris and Greenwich united their efforts in

* Paper read at the last general assembly of the Societe Astronomique de France, April 9, 1902, by M. Henri Poincaré.—Extracted by Paris Correspondent of the Scientific American.

the common enterprise of determining the difference of longitude between the two points. The preceding attempts showed divergences which were inadmissible and unexplained. The operations will be carried out in two series, at several months' interval. At present Mr. Dyson, a skilled English observer, is working at Paris at the same time as M. Bigourdan, while M. Renan is working at Greenwich during the same time, along with his English colleague. An exchange of observers will be made afterward.

Eros is now receding from us. The short period of its opposition has been well employed. One of the points which attracted the attention of astronomers has been the variability of the planet. Some attribute to it a period of 2½ days, and others a double period comprising two maxima which are unequal and not equidistant. Three explanations have been proposed. The planet may have a satellite almost as large as itself; again, it may not be spherical; or the surface presents bright and dark spots. The last hypothesis is the most simple. The systematic observations of Eros have been accumulated, but these have not yet been reduced. There is no doubt that from them will be obtained a better determination of the distance from the earth to the sun.

An ingenious but somewhat complicated hypothesis is that by which M. Arrhenius seeks to account for the different celestial and terrestrial phenomena. Maxwell has demonstrated mathematically that the luminous waves produce a pressure upon bodies. The experimental proof has not yet been made, but the question is being tried. In this way the sun should repel all bodies at the same time as it attracts them, but as the repulsion is proportional to the surface and the attraction to the mass, the repulsion would be comparable to the attraction if the body is very small, and it would be equal and even exceed it in the case of minute spherules of a few thousandths of a millimeter diameter. It is this repulsion which forms the tails of comets and the rays of the solar corona, formed of small microscopic spherules like those of a fog. In the interplanetary spaces themselves there should be small spherules of the same kind, although much rarer, and they are constantly moving away from the sun. Besides this dust, the spaces contain gases decomposed into ions. According to recent experiments, the negative ions have a condensing effect upon surrounding bodies and thus become rallying points for the traveling spherules. The latter thus become charged negatively, and constantly bring to the earth (as to the other planets) a series of negative charges. In this way may be explained the negative charges of the globe and hence the phenomena of atmospheric electricity. The negative potential will not, however, increase beyond all limits, first because the planet will finally repel the negatively charged particles, and second because the ultra-violet rays of the sun tend, as is known, to discharge negative bodies. The negative particles are, so to speak, minute cathodes, and in penetrating into the upper regions of the atmosphere will emit cathode rays; these will be invisible as the air is too rarefied to become phosphorescent. But these rays, which can be deflected by the magnetic field, will have a tendency to follow the earth's lines of force and will penetrate into the lower regions of the atmosphere at the same time as these lines, or at the polar regions; they will then encounter an air which is less rarefied and thus produce luminous phenomena. This is the origin of the aurora borealis. The globe would repel a part of the negative particles with which the sun bombards it, since it is negatively charged; this would make a sort of tail analogous to that of a comet and would be the zodiacal light. The celestial bodies thus not only exchange force and light, but matter as well. The interstellar spaces would be traversed by these minute projectiles and if the nebulæ are brilliant, although extremely cold and rarefied, it is under the cathodic afflux which comes from far-off stars.

According to M. Berkeland, an eminent Norwegian astronomer, the cathodic rays emanate directly from the sun and come from the most active part of the sun's surface, that is, in the neighborhood of the spots. These rays give our globe its negative charge and keep it up in spite of the loss due to the ultra-violet rays; they are attracted at the earth's poles and this accounts for the aurora borealis which is always produced at the polar regions. The characteristic feature of his theory is that in the interior of the sun there is a solid nucleus whose period of rotation is 25.15 days. It is above certain regions of the nucleus, which may be compared to volcanoes, that the sun-spots take their origin. This is the conclusion which he reaches after a great number of observations of spots.

EL GRAN CHACO.*

El Gran Chaco, the most mysterious region on the South American continent, has been the cause of the death of another band of explorers, again the Pilcomayo River has proved itself deserving of the title given to it by the natives of Paraguay, Argentina and Bolivia—River of Death.

The last victims of the unknown region are the famous Italian explorer, Guido Boggiano, and his party. From Asuncion in Paraguay the news has reached American geographers that the party has been officially pronounced dead.

With the death of Boggiano, El Gran Chaco, triumphantly keeping its secret, has successfully defied five nations—France, Spain, Germany, Italy and Paraguay. Each of them sent its best explorers and none returned alive.

Creveaux of France, Ibarreta of Spain, Lista of Paraguay, Sirvent of Germany and Boggiano of Italy, all started from the borders, dived into the primæval forest of El Gran Chaco, reached the Pilcomayo River and disappeared forever. No man has gone in and emerged alive.

Look on the map of South America. Between the Tropic of Capricorn and latitude 30 south, and between longitude 58 and 65 west, is a patch that is left almost entirely blank. That patch contains more than seventy-five thousand square miles about which man knows nothing.

Five months ago Guido Boggiano started from Asuncion with an expedition of six Indians and a peon to follow the path that so many others had taken before him and that had led them to death. Friends had urged him in vain to desist. Local officials had added their warnings without effect.

Men heard from him only once after he had left civilization, as he passed through Puerto Casado. Then came a week of silence, broken by the arrival of two of the expedition.

Even in that one week hardships and terrors had become too much for them and they had fled toward settled country. They reported that the line of march had been through constant dangers and through constant mystery.

Unseen enemies had attacked them by day and by night. Unseen animals had prowled on their trail. Unseen things had terrified the Indian helpers so that even then Boggiano was finding it almost impossible to force them on.

This is the last that has been heard of Guido Boggiano and his party. A month ago an expedition under local officials started out from Puerto Casado to search for news of the lost men.

It penetrated only a few miles into the unknown land—not far enough to find even a trail, but far enough to learn that there was no doubt that the entire expedition had been destroyed, presumably by the fierce, practically unknown, Tobas Indians. This makes the second expedition to vanish within a year.

First to meet fate in El Gran Chaco was Dr. Creveaux. He started into the interior in 1886 with a large and well-armed party, attracted by wonderful stories of strange, tall, savage men, strange wild beasts of huge size and a profusion of new orchids and other fantastic plants and creatures that were said to be in abundance there.

He forced his way for several months through the wilderness along the Pilcomayo until he penetrated into the Tobas country, near the Bolivian boundary, where the party, worn and thinned out by constant fighting and hardships, fell into the hands of the Indians, who suddenly appeared from all quarters and massacred all.

The fate of the Creveaux expedition only served to increase the eagerness of explorers to tear the veil that hid the unknown land. And that eagerness was next to cost the life of one of the most successful and earnest and daring explorers that ever was in South America.

He was Ramon Lista, to whom the world to-day owes much of its knowledge of Paraguay, Argentina and Patagonia. For many years he had lived almost constantly in the wildest parts of the continent.

He was the first man to send out from the depths of Patagonia the report of the possible existence there of a monstrous animal, the mylodon, a giant sloth as great as an ox, that still survived from prehistoric days. He reported subsequently that one evening he had even shot some huge creature that might have been the animal sought for. For its hide turned the bullet, and the gloom of the forest made pursuit impossible.

Ramon Lista set his face toward El Gran Chaco. He passed beyond the uttermost frontier of human dwellers, and with canoe and men paddled away to reach the Pilcomayo River. And when he paddled thus away he passed out of human sight forever. For the River of Death has never given him up.

Fragments of his story have drifted to the outer world, and from the stories told by boastful Indians and the scattered rumors brought to Bolivian and Paraguayan and Argentine frontier posts, it is known that he forced his way far up the river, contending against nature, and wild beasts and wild men alike, until, thoroughly worn out and diminished in numbers, the party found themselves cut off from either retreat or advance by the allied forces of human foes and hunger.

For the Indians, rarely showing themselves, but constantly lurking around the party, not only picked off any members of the expedition who strayed from the main body, but prevented all hunting. At last the party was so reduced by privations that panic seized some and despair others.

And then came annihilation, so that none returned. Lista himself, so men have learned since then, was one of the last to die. He was brained while he lay starving. And scattered over many miles of forest trails lie his companions, pursued and killed in flight.

Ramon Lista's fate well might have deterred other men from seeking to enter the somber precincts of the *terra incognita*. Yet rumors of Lista's loss had not more than begun to reach Europe and North America, and already another expedition was preparing.

Col. Enrique de Ibarreta of Spain was the man to lead it. He made his start from San Antonio in Bolivia with a party equipped as if for contest rather than for exploration. He had a flotilla of Indian canoes, each holding twelve men, and with him were six Argentines, two Bolivians and one Spaniard, all well fitted by knowledge and experience for the work of carrying out the task of forcing the passage through the River of Death. The canoes were covered with heavy sails and skins, which were pierced with loopholes for rifles.

At Fort Creveaux, named in honor of Dr. Creveaux, he got additional force in the form of two friendly Pilagas Indians and an Indian boy, who proved invaluable through his knowledge of the many languages and dialects of the tribes that were encountered during the voyage. Col. Suarez, acting in command at the fort, provided this escort under orders from the Bolivian government, but personally begged Col. Ibarreta to desist.

His arguments were vain and early in June the party started down the Pilcomayo. And scarcely had they passed from the sight of the soldiers in the frontier fort before the forest was alive with dangers all around them. Men dared not leave their covered canoes, even in the daytime.

Game vanished strangely before them. At first it seemed unaccountable, until they found that the Indians, invisible, but ever present, were driving it away to starve the explorers out, so that they should venture into the forests to hunt, when they could be killed easily.

When the expedition reached Lagune Pitano, less than three hundred miles from the place where they had started, it was September. It had taken them more than three months to get there, and yet the mysterious land had scarcely been entered.

And the men were then in such extremities that Ibarreta saw that they could not hope to get out alive unless help reached them. They were encompassed by savages. Food was reduced to a minimum.

In this crisis Col. Ibarreta called for volunteers to break through the silent, hidden cordon of foes and try to reach Formosa, on the Paraguayan boundary to get help. Eight men offered themselves for this service.

Of these eight men nothing has been learned to this day, with the exception of two, who were found wandering in the thickets with barely strength enough left to tell even the briefest story. They had been hunted headlong from mile to mile. Six of the fugitives were killed before a day had passed.

The two survivors said that they had left the Ibarreta party in dire need. Just before passing certain great waterfalls of the Pilcomayo River, the hitherto deserted banks of the gloomy stream suddenly were filled with tall men, hideously painted and armed with huge knotted clubs and with spears.

Their faces, painted coal black, with circles of light blue over the cheekbones and three blue streaks, radiating from the corners of their mouths, made them look like devils. Indeed, the Pilagas Indians—a friendly tribe living near the borders—affirm that these are devils and not men that haunt the dark, impenetrable forests of the River of Death.

The Indians made an attack in force on the expedition and were beaten off only after desperate efforts. They withdrew then into the cover of the overhanging vegetation on the banks, but never ceased harassing the explorers.

To go ashore for food was out of the question. The only hope that was left when the men started for relief was to press on slowly to find a landing place in open country, where the Indians might be at a disadvantage.

The two men did not live to reach civilization, but died near where the friendly Indian hunters had found them. These carried the news to Col. Carmelo Uriarte, who quickly formed a relief party and advanced toward the Pilcomayo.

For twenty days he marched and paddled, and for all those twenty days he had to fight the savages who attacked him from every hiding place along the line. His Indian guides found friends who told them that the Ibarreta party had been annihilated, and they led Uriarte and his men to the spot where Col. Ibarreta, the last man to yield, had made his final fight.

The murderous Indians were members of the Chorotis and Orejude tribes, of whom little is known except that they live a life of constant warfare between themselves, sinking their differences only when strangers enter the country.

Uriarte's spies found the graves of various members of the Ibarreta party and returned with stories of courage and devotion. They learned how one member of the expedition after another had died either from starvation or wounds, and how the survivors had buried their comrades and planted a rude cross on each grave.

At last there were left with Ibarreta only a single Indian and the boy. These three worked their way on, ever suffering more, until they were unable to wield either paddle or pole.

Then they crawled out on the bank and while they were plodding on shore, entirely exhausted, the Indians stole on them and killed them with axes, Ibarreta fighting until the last and not yielding until he was powerless to move.

And still El Gran Chaco was to have more victims. While Boggiano's fate was still unknown, Capt. Sirvent, a German instructor in the Chilian army, started with his son to enter the Chaco country from the west.

He expected to return in a month. But three months passed and no sign came from the unknown land.

Now, according to news just received, Capt. Rojas of the Paraguayan army, who started from the east to search for him, has returned to Villa Hayes—named after R. B. Hayes, to commemorate his settlement of the Paraguay-Argentina boundary dispute—with almost positive information that this expedition also has been destroyed.

Capt. Rojas found that it had approached the vicinity of the scene of Ibarreta's death, and there, on the banks of the Pilcomayo River, had perished, to prove anew that the River of Death still defies the world's efforts to dispel its mystery.

* New York Sun.

THE ROLAND PILLARS.

In many parts of Germany one finds in market towns a rude effigy in stone called Rolandsäule, which is supposed to represent the famous Paladin of Charles the Great. There was one in Berlin which suffered ignominious treatment owing to the changes in taste and is now deeply regretted by the local antiquarians, while a number of the minor towns of Prussia find their old market-statue the most attractive thing to show visitors. Most famous of all is the Rolandsäule at Bremen. The enormous popularity of the versified tales in which Roland figured from the tenth century onward throughout the west of Europe may account for these statues; or, if they were not originally meant as monuments to Roland, may explain the attribution of them to the Paladin. In France a suggestion has been made to erect a memorial to Roland, who was an historical personage named Hruodland, Prefect of Brittany under Charles the Great. He was overwhelmed with the rearguard in 778 by the Basques while retreating from Spain. Hruodland, or Orlando, as the Italians called him, is certainly one of the most famous Frenchmen known to history, about whom a more poetic nimbus has gathered than about Charles the Great or Napoleon. So a fund has been launched in Paris which, when large enough, is to provide that fair city with a monument to the hero

of a thousand songs, epics, plays, a Teutonic general whose character has been invested with traits borrowed from Celtic culture-heroes and ancient Romans of history and romance. The German colossal statues named for Roland in all probability were erected by citizens of certain towns to attract the ignorant, half-pagan rustics, thus affording them a substitute for their old idols, and they were placed at the town-hall or in the market so that bargains might be sealed before them. The Paris Roland will form only one of a thousand statues which attract Christian as well as pagan foreigners to the French capital.—New York Times.

[Continued from SUPPLEMENT No. 1394, page 22345.]

A REVIEW OF THE EXISTING METHODS OF CULTIVATING ANAEROBIC BACTERIA.*

By OTTO F. HUNZIKER.

REPLACEMENT OF AIR BY INERT GASES.

THIS principle has been employed by Pasteur in the study of his *Vibrion butyricus* as early as 1861. He cultivated this organism in an atmosphere of hydrogen

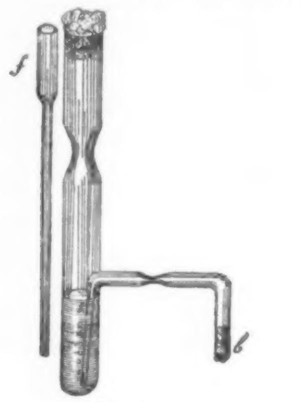


FIG. 8.

and carbonic acid. Since then many methods of this type have been introduced and put in practice. Of the various gases that have found application as a means of replacing the air, hydrogen proved to be, everything considered, the most satisfactory.

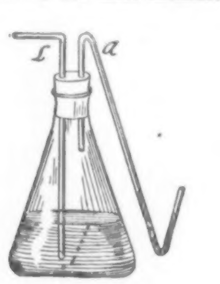


FIG. 9.

Hydrogen is produced most conveniently by means of the Kipp generator, dilute hydrochloric acid and metallic zinc being used. The hydrogen thus produced is freed from traces of AsH_3, SH_2 and PH_3 that may be present, by passing the gas through concen-

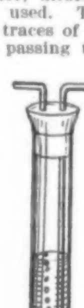


FIG. 10.

trated $KMnO_4$, from acids that may have been carried over from the generator by passing it through concentrated KOH, from traces of oxygen by passing it through an alkaline solution of pyrogallol, and from water by passing it through dry $CaCl_2$ or concentrated

FIG. 11.

H_2SO_4. If chemically pure zinc is used, washing is not necessary.

When a union is to be made between two glass tubes by means of rubber tubing the ends of the glass tubes should meet. This avoids the direct exposure of large surfaces of rubber tubing to the action of hydrogen and prevents the diffusion of hydrogen through

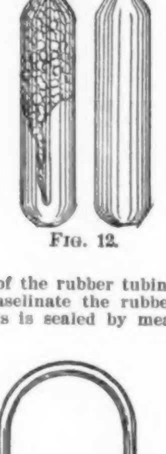


FIG. 12.

the porous walls of the rubber tubing. In any case it is advisable to vaselinate the rubber tubing.

If the apparatus is sealed by means of glass turn-

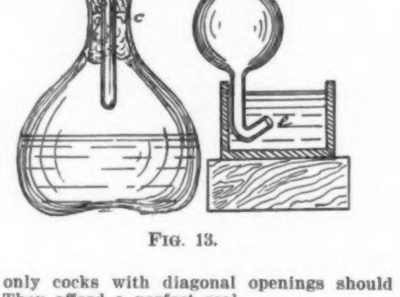


FIG. 13.

cocks, only cocks with diagonal openings should be used. They afford a perfect seal.

High pressure in the apparatus tends to seriously

FIG. 14.

affect the cultures and should therefore be avoided. Slight over-pressure which will not materially disturb growth is desirable as a means of preventing

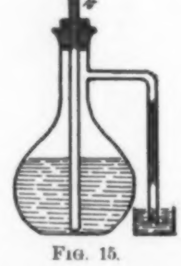


FIG. 15.

any possible diffusion of gases. Where convenient it is well, instead of filling the apparatus with hydrogen and sealing it hermetically, to pass the hydrogen through the apparatus continually during the whole period of cultivation. In this case the hydrogen, upon leaving the culture apparatus, is conducted through a doubly perforated rubber stopper to the bottom of a wash bottle containing distilled water.

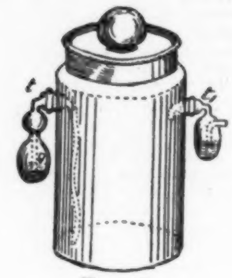


FIG. 16.

The water forms a hermetical seal, preventing the air from entering the apparatus in case the gas pressure should diminish.

The purity of the gas in the culture apparatus is tested by filling a test tube with the escaping hydro-

FIG. 17.

gen and applying a match to it. If the gas burns with explosion, the apparatus still contains some atmospheric oxygen; a quiet flame indicates pure or nearly pure hydrogen.

A. CULTURES IN TUBES AND FLASKS.

Hauser and Liborius (1886) introduced the appar-

FIG 18.

atus shown in Fig. 8. A short distance above the surface of the medium the test tube carries a lateral tube, constricted near its union with the test tube, and cotton-plugged at its outer opening. The test tube is also constricted below the lower end of the cotton plug.

Method.—Introduce the medium into the test tube

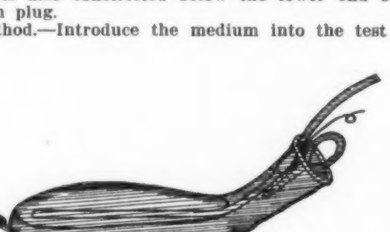


FIG. 19.

by means of the drawn-out funnel, *f*, replace the cotton plug and sterilize as usual. Inoculate the medium and connect the end, *b*, of the lateral tube with the Kipp generator. Pass gas through for fifteen to thirty minutes. In case gelatin or agar is used stand the test tube in a water bath at 40 deg. C. while the gas is introduced. Now seal first the test tube and then

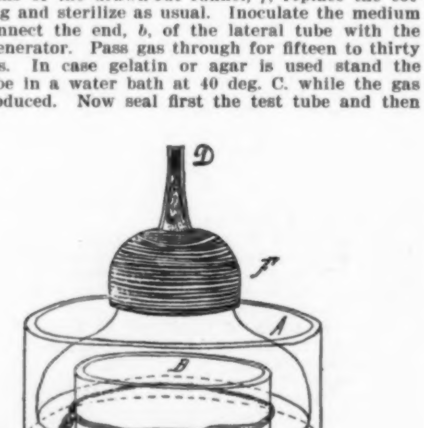


FIG. 20.

the lateral at their respective constrictions in the flame. Similar apparatus have been constructed by Exner, Buchner and Roux. For agar, blood serum and potato slant cultures Liborius arranges the medium so that the slanted surface is opposite the lateral tube.

Hueppe closes the test tube or flask (Fig. 9) con-

* Journal of Applied Microscopy and Laboratory Methods.

taining the inoculated medium with a doubly perforated rubber stopper. In one perforation rests a glass tube, *L*, which reaches to the bottom of the flask, the other holds the glass tube, *A*, containing at its lower curve a small amount of mercury.

Method.—Introduce hydrogen at *L*; the air is forced

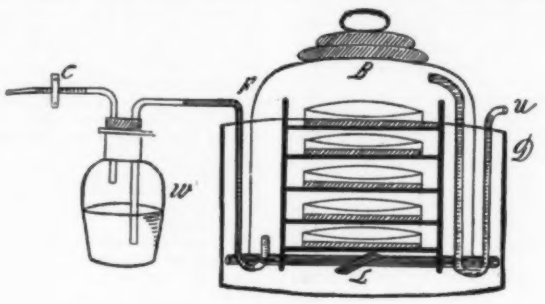


FIG. 21.

out through *A*. Having passed hydrogen through the tube for from ten to twenty minutes, seal the glass tube, *L*, in the flame. The mercury in tube *A* serves as indicator of the changes in pressure, which may take place as the result of gas production by the growing bacteria in the tube or flask. If this indicator is not desired, a short glass tube is used in the place of tube, *A*, and when all the air is replaced by hydrogen the glass tube is sealed in the flame.

Fraenkel's method (1888): Into a test tube (Fig. 10) containing liquefied inoculated gelatin or agar, insert a doubly perforated well fitting rubber stopper carrying two glass tubes; one reaching to the bottom of the test tube, the other to the lower surface of the stopper. Cover the top of the rubber stopper and test tube with an air-tight layer of paraffin or sealing wax. Introduce hydrogen through the long glass tube. When all the air is replaced by the gas, seal first the exit and then the entrance tube over the

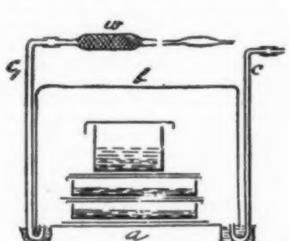


FIG. 22.

flame, and roll the test tube until the medium is congealed.

For agar stick and stab cultures, Blucher (1890) recommends the following method:

Reverse the inoculated test tube (see Fig. 11), remove the cotton plug; with the open end downward dip the test tube into a beaker containing a solution of diluted glycerin (equal parts glycerin and water). By means of glass tube, *g*, introduce hydrogen into the test tube. In about five minutes all the air is replaced by the gas, the generator is disconnected, and the beaker containing the test tube is put into the incubator.

Hesse (1890) modified Blucher's methods by inverting the inoculated test tube into mercury instead of glycerin.

Fuchs (1890) rejects the condensation water from slanted blood serum tubes, inoculates the slanted surface, reverses the tube and introduces hydrogen for about five minutes. Without changing the position of the test tube he then inserts a tightly fitting, sterilized rubber stopper and seals hermetically by dipping the sealed part of the tube into liquid paraffin.

Ogata (1892) used a method very similar to that of Liborius. Instead of introducing the gas through the lateral tube as Liborius did, Ogata does away with the lateral tube and conducts the gas down into the medium by means of a capillary glass tube running through the cotton plug of the test tube down to the bottom of it (see Fig. 12). The air is slowly forced out of the tube in form of gas bubbles, some of which collapse, others form foam. As soon as the foam has

FIG. 23.

passed up through the narrow part of the tube, the capillary tube is removed, and while there is still foam in the upper portion of the tube the constriction is sealed over the flame.

Heim (1892), who claims to be the inventor of this method, recommends that, except when Esmarch roll cultures are made, the test tube should be sealed without removing the capillary tube; that the inoculation should be made before the tube is constricted, and that the constriction should not become wet, as the glass is liable to crack during the operation of sealing in the flame.

For liquid medium Roth (1893) used an upright flask (see Fig. 13). In the lower part of the neck rests a cotton plug, which is attached to a wire running out through the flask. Through the cotton plug passes one end of a glass tube, the other being conducted into a cup of glycerin.

Method.—Fill the flask about half full with liquid medium, press the cotton plug, *c*, well down into the neck, push the glass tube down near the bottom of the flask and connect the other end of it with the gas generator. When all the air is replaced by the gas, and before disconnecting the apparatus from the generator, raise the glass tube out of the medium as

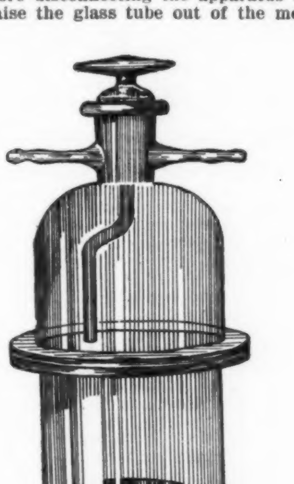


FIG. 24.

shown in Fig. 13, immerse the other end of the glass tube in glycerin, fill the neck above the cotton plug with paraffin and disconnect at *e*. The flask is opened by heating the neck in the flame and raising the plug by means of the attached wire. In case of very large flasks Roth covers the cotton plug with a piece of rubber containing an opening for the introduction of the glass tube before the apparatus is connected with

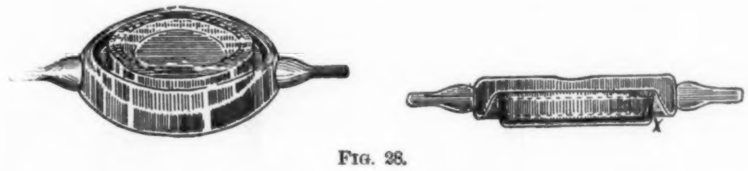


FIG. 28.

the generator. This will increase the pressure from within and prevent any possible entrance of air during the introduction of gas.

Novy (1893) devised an apparatus which allows a large number of tube cultures to be made simultaneously. The apparatus as shown in Fig. 14 consists of a cylinder 20 by 10 centimeters (not counting the neck). The neck carries two lateral tubes. Into the neck of the cylinder is fitted a glass stopper with ground surface. The glass stopper also carries two perforations on opposite sides corresponding to those in the neck. From the inside of the glass stopper one of the perforations is connected with a glass tube,

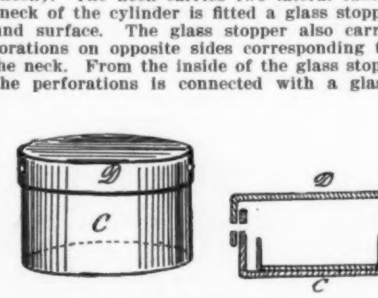


FIG. 25.

reaching nearly to the bottom of the cylinder. If a gas heavier than the air is introduced the glass stopper should be turned so as to conduct the gas through the tube in the interior of the bottom of the cylinder, thus allowing air to escape on top through the other lateral tube. In case of a gas lighter than air, as, for instance, hydrogen, it should enter the cylinder on top, forcing the air out through the long tube reaching to the bottom of the cylinder.

Method.—Inoculate forty to fifty ordinary culture tubes (12 to 15 centimeters long). Insert loose cotton plugs and cut them off at the end of the tubes. With a pair of long tongs place the tubes in the cylinder, the bottom of which is covered with cotton, cover the surface of the glass stopper with paraffin or vaseline and insert the latter in its place, care being taken that the perforations in the stopper correspond with those in the neck of the cylinder. Connect the apparatus, as above directed, with the gas generator and lead the exit tube into a wash bottle containing

FIG. 26.

water. After passing the gas through for from one to two hours, carefully turn the glass stopper an angle of 90 deg., disconnect the cylinder and put it aside for the development of the bacteria. If instead of replacement by gas the cylinder is evacuated, it becomes impossible to turn the glass stopper. In this case each lateral tube carries a small glass turncock for the purpose of sealing the apparatus when exhaustion is complete.

Hewett (1894) recommends for bouillon cultures the use of a yeast flask of 90 cubic centimeters' capacity. The flask is closed by a monoperforated, well-fitting rubber stopper through which a glass tube passes to the bottom of the flask. The part of the tube extending above the stopper is cotton plugged. A lateral tube projects from the side of the neck as shown in Fig. 15. The lateral tube is also plugged with absorbent cotton. It leads into a cup containing mercury, the latter forming a valve. The surrounding air cannot enter, while the interior air and the gases formed by bacterial activity have free exit.

Method.—Fill the flask about two-thirds full with glucose bouillon, sterilize, cool and inoculate the medium. Introduce hydrogen through the glass tube in the rubber stopper for one hour; before disconnect-

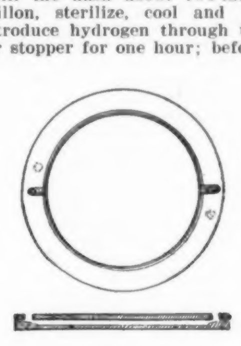


FIG. 27.

ing the generator dip the end of the lateral tube into the cup containing mercury, and seal tube, *b*, above the rubber stopper in the flame.

Lubinski (1894) constructed two forms of apparatus. One of these resembles that of Novy so closely that it need not be described here. The second apparatus is illustrated in Fig. 16. It is closed with a ground glass stopper. Immediately below the neck the cylinder carries at two diametrically opposed places tubes, *t*, and t_1, ending in glass bulbs. Both bulbs are partly filled with liquid paraffin or vaseline. In order to prevent the liquid in bulb, *t*, from passing over into the apparatus, bulb, *t*, is separated from the cylinder by a second bulb. The gas is introduced through bulb, t_1; bulb, *t*, serves as exit for the air. As in Novy's apparatus the entrance of gas and exit of air take place at different heights. The manipulation is very similar to that of Novy.

Jacobitz (1901) successfully made agar slant cultures in nitrogen atmosphere. He used Fraenkel's tube. Into the boiling hot agar he introduced a current of nitrogen purified by running through con-

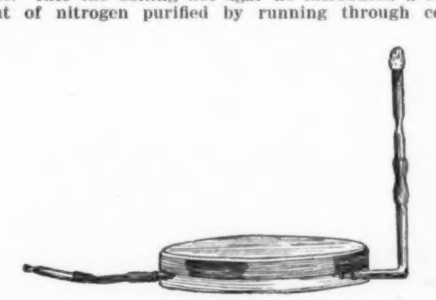


FIG. 29.

centrated sulphuric acid, through alkaline pyrogallol and through potassium hydroxide. He then lays the tube on an ice tray to slant the agar, continuing the current of nitrogen until the agar is congealed. After inoculating in the usual way more nitrogen is introduced. Finally the entrance and exit gas tubes are sealed hermetically in the flame.

B. PLATE CULTURES.

Kitasato (1889) used a flattened receptacle about

2 centimeters thick (see Fig. 17) for the isolation of tetanus. The manipulations of the apparatus resemble those employed in the case of Liborius tubes. The two openings are plugged with cotton and the apparatus is sterilized. Then the surface tube, *b*, is constricted in the middle. With a well-drawn-out funnel about 20 cubic centimeters of the liquefied inoculated medium are poured through the opening at *a* into the receptacle, then *a* is also constricted. Having passed hydrogen through until all the air has escaped, the two ends, first the exit, then the entrance, are sealed in the flame.

Roth (1893) recommended a similar device. His apparatus is illustrated in Fig. 18. It is used for solid medium.

Method.—Plug both openings with absorbent cotton and sterilize. The plug at *a* carries a corkscrew, that at *b* is attached to a fine copper wire. Introduce about 8 cubic centimeters of the liquefied medium (gelatin or agar) and sterilize on three successive days. For this purpose the flasks may be stood upright in wire baskets. After inoculating in the usual way, let the medium congeal. Then push by means of the corkscrew the plug at *a* down far enough to touch the medium; introduce hydrogen at *b* by connecting *b* by means of rubber tubing with a generator. The rubber tubing carries a clamp. In order to prevent the mixing of air and gas as much as possible, it is best to incline the apparatus so that the neck points downward. When all the air is replaced by the inert gas pour a little melted paraffin on the cotton plug in the neck. When congealed dip tube, *b*, into liquid paraffin and remove the rubber tubing. The plug in tube, *b*, is thus saturated and the tube filled with paraffin. This paraffin seal proved very satisfactory. In order to get access to the grown colonies warm the neck and pull the cotton plug out by means of the corkscrew.

For making cultures in the field Roth used a similar apparatus (see Fig. 19). In order to avoid breakage, the small tube, *b*, shown in Fig. 18, is discarded and the hydrogen is introduced in the laboratory. For this purpose a small cotton plugged sterile metal tube is inserted in the apparatus. When the air is all driven out, the neck is filled with paraffin and the metal tube carefully removed by means of a copper wire which had previously been attached to it.

Blucher (1890) recommends the apparatus illustrated in Fig. 20. A funnel-shaped bell jar with a cotton plugged opening, *D*, and weighted down with lead, *F*, rests in a glass bowl, *A*. The petri dish is kept in its place by means of a spring wire ring with three projections reaching to the walls of the bowl.

Method.—Pour the inoculated medium into the open petri dish, *B*. Place the bell jar over it and pour into the glass bowl diluted glycerin (1 part glycerin, 3 parts water) until the interior is completely separated from the exterior. Introduce hydrogen through the opening at *D*. The air escapes through the glycerin in bubbles. When all the air is out, generally after about 10 minutes, close the rubber tubing at *D* by means of a clamp, cut the tubing about 2 centimeters above the clamp and fill the end with glycerin. The freedom of the apparatus from oxygen can be tested as follows: Bring a burning match close to the glycerin in the bowl where the bubbles escape. If the latter burn regularly and without explosion, the apparatus may be considered oxygen free. In order to obtain access to the petri dish when the culture has developed, carefully and slowly raise the bell jar on one side, allowing small bubbles of air to enter. This will prevent the glycerin from spattering into the culture.

Botkin's apparatus (Fig. 21) is a modification of that of Blucher. It contains a glass dish, *D*, 20 to 25 centimeters in diameter (much the same as those used for potato culture). In the dish, *D*, stands a wire support for the petri dishes, which are covered by bell jar, *B*. The latter has a diameter about 3 centimeters smaller than dish, *D*. It does not touch the bottom of *D* directly, but it rests on a cross band of lead, *L*, 1 centimeter in thickness. U tube, *U*, is a thin rubber tube; its lumen contains a fine, soft and flexible copper wire. Opposite tube, *U*, there is another similarly constructed rubber tube, *F*, leading from the interior of the bell jar into a wash bottle, *W*, containing water and closed by a doubly perforated rubber stopper; the second perforation carries a glass tube continuing into a rubber tube and closed by a clamp, *C*.

Method.—Disinfect the interior of the apparatus by washing with a solution of sublimate and drying with alcohol and ether. Sterilize the wire support in the flame. Prepare the culture plates in the ordinary way and place them on the wire stand. Pour a layer, 3 centimeters high, of paraffin liquidum, preferably Buchner's mixture (1 part glycerin to 3 parts water) into dish, *D*. Insert the U tubes in their respective places and cover with the bell jar. Introduce hydrogen through tube, *U*. The air escapes in bubbles through the glycerin in dish, *D*. In about ten minutes open clamp, *C*, allowing the air in wash bottle, *F*, to escape. After two more minutes light the gas escaping at *C*. If the apparatus contains pure hydrogen the escaping gas will burn with a quiet, even flame, otherwise with a crackling noise. Being assured of the complete replacement of air by hydrogen, carefully withdraw the U tubes, *U* and *F*, from the apparatus. In order not to disturb the glycerin seal by transportation, Botkin recommends placing the apparatus in the incubator before hydrogen is introduced.

Hesse (1892) introduced the type of apparatus shown in Fig. 22. It consists of the following parts:

a. A cast iron plate 20 centimeters in diameter, with a channel (2 centimeters wide and 3 centimeters deep) at its periphery; on one side the channel is 2½ centimeters deeper than at the other. It is filled with mercury. The plate is smeared with shellac.

b. A bell jar fitting into the channel and floating on the mercury.

c. Two U tubes, *c* and c_1, with extensions for the entrance and exit of gas and air respectively. Tube, c_1, contains at *w* a wire gauze to insure a safe test of the escaping gas by burning.

Method.—Cover the center part of plate, *a*, with a blotting paper for the purpose of absorbing moisture. Upon this place the inoculated, loosely-covered plate cultures, invert the bell jar over them and insert the U tubes, *c* and c_1, in their proper places. Connect *c* with the Kipp generator. The purity of the escaping gas is tested by applying a burning match to the capillary end of the tube, *c*.

Baginsky constructed an apparatus (Fig. 23) that appears to be simple in construction and easy to manipulate. It consists of a large metal plate, the circumference of which is covered with a thick rubber ring. A bell jar is inverted over the plate and rests on the layer of rubber. Over the bell jar is placed a metal plate similar to that which forms the bottom of the apparatus. The bottom part contains four projections in which are hinged metal rods, the outer ends of these rods fit into similar projections in the cover plate. By means of these four metal rods the upper and the lower metal plates are tightly pressed against the bell jar, closing the apparatus hermetically. On opposite sides the bell jar contains small lateral tubes by means of which hydrogen is introduced and air driven out.

Method.—Place the inoculated petri dishes upon the bottom plate of the apparatus. Invert the bell jar and seal the apparatus by screwing the upper and lower plates firmly against the bell jar. Introduce hydrogen at the upper lateral tube, the air will escape through the other. When all the air is driven out, which is determined by the hydrogen tube test, seal first the exit, then the entrance of gas and place the apparatus in the incubator. A very satisfactory way is also to run the hydrogen through continuously until the cultures are grown.

This apparatus is also well suited for a large number of tube cultures in hydrogen atmosphere.

Novy (1893) recommends his apparatus (Fig. 6), designed for plate cultures in a vacuum, also for plate cultures in hydrogen atmosphere. In this case hydrogen is introduced at one end of the glass cock, *x—y*, and the air escapes at the other.

In addition he modified his apparatus for tube cultures (Fig. 14) so that plates can be placed in it (see Fig. 24.) Its manipulation is the same as that for the tube cultures.

Kedrowski's apparatus (Fig. 25) consists of a deep glass plate, *C*, with cover, *D*. On the sides at diametrically opposite points plate and cover are perforated for the entrance of gas and the exit of air.

Method.—Into the sterile plate, *C*, put an open petri dish containing the inoculated medium. Coat the inside of the rim of cover, *D*, with vaseline. Place *D* over *C*, so that the perforations in plate and cover meet perfectly. Introduce hydrogen, and when the gas has replaced all the air, then turn the cover 90 deg. and put the apparatus into the incubator.

Gabritschewsky's plate (Fig. 26) consists of a subplate with a rim at its periphery. The outer end of the rim is so constructed as to expose a broad horizontal surface for the cover to rest on. This surface is perforated at two diametrically opposite points corresponding to two similar perforations in the cover.

Method.—Pour the inoculated medium into the central part, *c*, of the sub-plate. Cover with a paraffined ground glass cover so that the holes in the rim correspond with those in the cover. Introduce hydrogen and when all the air is replaced, carefully turn the cover 90 deg., sealing hermetically. In addition Gabritschewsky recommends the use of an alkaline solution of pyrogallol which is poured into the rim before the gas is introduced.

A similar plate (Fig. 27) was constructed by Kamen. Its method of manipulation is exactly the same as that of Gabritschewsky.

In case of Beck's plate (Fig. 28) a common petri dish is used. It is covered with a plate carrying two lateral tubes for the introduction of gas and exit of air. The periphery of the cover is so shaped as to form a small reservoir which may be filled with water in case of cultures that require a long period of incubation. By means of short pieces of stout rubber tubing the laterals are connected with short constricted glass tubes which are sealed in the flame when the plate is oxygen free.

Method.—Pour the inoculated medium into the sterile plate and put the cover in its place. When the medium is congealed fill the rim, *X*, between the plate and the cover with liquefied paraffin. When this is solidified replace the air by gas and seal the constricted tubes in the flame.

Aren's plate (Fig. 29) consists of an ordinary petri dish carrying lateral tubes which open into the interior of the plate. The space between the rim of the cover and that of the plate is filled with liquefied paraffin. When the air is expelled by gas the laterals are sealed in the flame.

Epstein's plate is a modification of that of Aren. Instead of the lateral tubes of glass similar tubes of firm rubber are used. The rubber tubes are a part of a solid rubber band that covers the periphery of the plate. When the hydrogen has replaced the air the plate is sealed by pushing well-fitting glass rods into the lateral rubber tubes.

(To be continued.)

TREASURES OF SAVAGES.*

THE treasures of savages are not gold or silver generally. Though the precious metals may be valued for ornament, much intercourse with white men is needed to make them think of storing bullion. Poor old Lo-Bengula was credited with an enormous hoard of nuggets, but he, and his father also, were familiar with white traders. Even now one may hear Afrikanders thoughtfully computing the value of that hoard and speculating where it lies hidden. The wealth of the King of Momotopata was a proverb in Europe for generations. When Ancient Pistol sang of Africa and Golden Joys he was thinking probably of that story. For two centuries no one doubted that in East Africa, behind the Portuguese settlements, dwelt a king whose riches were incalculable, ruling a vast dominion called Momotopata. In this prosaic age it has been demonstrated that the name was due to a misapprehension on the part of the first voyagers; that the natives did not use it; that there was not even a supreme chief, and certainly no fabulous store of gold. The treasures of savages are not commonly so matter-of-fact.

As a rule, indeed, they have no market value—sometimes European goods which have caught the popular fancy, but usually ancient and superstitious. When Bickmore was traveling in Sumatra thirty years ago he found a curious example of the former class. His servants constantly told him of wonderful rings taken from the heads of snakes which Rajahs and wealthy men bought at a monstrous price and kept as the choicest of all their possessions. Some said the things were diamonds of this abnormal shape. At length Bickmore came across a friendly Rajah who was willing to show his curiosities, and among them he produced one of these rings. It proved to be a length of glass rod bent into a circle, the ends fused together—worth perhaps twopence in Europe, if anybody wanted it. How these things got to Sumatra could not be ascertained; there were not nearly enough of them to represent a consignment.

All natives of the Far East believe that stones and jewels are found sometimes in the heads of snakes, and the lucky mortal who persuades a rich man that the example he offers is genuine may command his own price. It is a potent charm, especially with the ladies. Still more precious is a horn of the mouse-deer, as it should be, seeing that the species is hornless; everyone believes, however, that very rare individuals may be found which have this equipment, and the material of it is brass. A specimen was offered to Rajah Brooke once; the vendor must have had a rare stock of impudence, or, what is more likely, he acted in good faith. The object appeared to be a human figure, in brass, an inch and a half high, perhaps Hindoo or Burman, but so worn that little shape remained.

The regalia of Malay sovereigns are national treasures, sacred and inestimable. A few sets are still preserved in the Federated States, under British protection; unfortunately, these are not of the first class, though as much venerated as any. The articles can only be touched by men of a certain tribe, or a certain family, and even by them only on fixed occasions. Mr. Skeat was allowed to examine the regalia of Selangor—a big drum and two small ones, two kettledrums and a trumpet, a flute, eight lances, adorned with cows' tails, a trident, a kris, a betel-box, the sword of state and two others, the royal umbrella and tobacco box. It is not an imposing list, but the people at large, and the inhabitants of the palace especially, regard these things with awe. Also they have a mortal fear of them, which is reasonable enough. For Mr. Skeat found them deposited in a great chest lined with tin, mounted on tall posts in the middle of a bare lawn; the Sultan explained that he had put them there for the safety of his children, friends and servants, who were killed off so fast by these holy but terrible objects that he could not stand it. His Highness himself showed them to the visitor. Most deadly of all is the sacred trumpet, but it is also the most curious, and Mr. Skeat took it in his hand, though the Sultan warned him. Next day, as it happened, his arm swelled so seriously that he had to leave the district for medical advice. Thus the awful majesty of the Selangor regalia was vindicated. But regalia exist in the same quarter of the world vastly more curious.

Most interesting of men are the Kings of Fire and Water, dwelling in the remotest parts of the Lao country—peasants, without an army or even a servant, but, in former times at least, exercising sway over Cambodia, Annam and Siam, not unconsidered perhaps even in Burma. Little do we know about these fascinating potentates, but until the French took possession of Cambodia, ten years ago, its monarch used to send costly presents as a tribute to their spiritual suzerains from time to time; getting a lump of beeswax and two calabashes full of rice in return. The insignia of the Fire and Water Kings are a fruit called cui, gathered ages ago, but still fresh, a rattan of the same antiquity and equally green, and a sword. More than once unscrupulous sovereigns have tried to capture these holiest relics, the possession of which would have given them control *de jure* over all the peninsula. But the attempts failed dismally.

Perhaps the most remarkable treasures of savages are the jars so highly esteemed by the Bornean Dyaks. The material is earthenware, and the manufacture Chinese beyond doubt, but of great antiquity. There are three sorts. The Rusa, comparatively common, is worth £6 to £8—about twelve inches high, of smooth, brown body, with figures of deer scratched upon it. Next comes the Naga, worth £15 to £100, two or three times as big, yellow, adorned with dragons. The Gusi is green, with figures, eighteen inches or two feet high, so rare and so valuable that no price can be quoted. It is recorded that a chief paid £700 for one, and declined to part with his bargain for any sum. The Sultan of Borneo has the finest, of course; but he never paid for them. These are described as exquisite specimens of earthenware. Sir Spencer St. John asked the late Sultan, with an air of business, whether £2,000 would tempt him to part with one; his Majesty declined without hesitation. In fact, he makes a good deal of money in times of death or sickness or calamity by selling water from his precious Gusis.

In Sarawak also and the Dutch territory the extreme reverence for these jars is utilized by government. Every tribe of importance has its store of them, used at seed time and harvest for sprinkling the fields with holy water. If criminals be not surrendered, or if the young warriors give trouble, the jars are seized as hostages. A rebellious tribe is fined so many Rusas or Nagas, or a Gusi, if it be known to possess one. Many attempts have been made to counterfeit them in Holland, China and Staffordshire without the smallest success. They are not found in the earth. There was a great Chinese population in Borneo once, and the jars were imported at that time probably. It is curious, however, that the cannibal Battaks of Sumatra also have precious jars of earthenware, used for just the same rites. We never saw a description of them. The precious Aggry beads, too, are found in Borneo, if travelers' reports be correct,

* London Standard.

but these are few and far between, unhappily. The beads in question appear to be used only by the Kaygans, the great tribe occupying the interior of the island, which has scarcely yet been visited by Europeans in peaceful guise. But fifty years ago Mr. Spencer St. John reached Baram, and there, on the wife of the great chieftain, he saw these beads. "The best appeared like a body of black stone, with four other variegated ones let in all round. The colors of the four were a mixture of green, yellow, blue and gray." A person unacquainted with Aggry beads would not describe them otherwise. And they are equally valued. "Were I to endeavor to estimate the price in produce which she and her parents had paid for this hip-lace, the amount would appear fabulous." The cheapest had cost 9s. each apparently; the dearest £35. And there were many hundreds of them, passing three times round her hips.

ADVERTISEMENTS IN NATURE.—HOW THE COLORS OF FLOWERS ATTRACT INSECTS AND BIRDS.

In the study of natural history the chief interest belongs, not to collecting and classifying, but to interpretation. We are surrounded by natural things, animate and inanimate, and each has a purpose beyond the universal one of being beautiful. To the human understanding is presented the fascinating problem of finding out what that purpose is. Brilliant minds, capable of original conceptions and accurate investigations, have long been busy to that end; and now in many domains light is dawning, though day may still be distant. Meanwhile, as ever, phraseology lags behind discovery. New truths are anonymous and only to be described with roundabout verbal clumsiness.

Thus "advertising in nature" is but a make-shift nickname for a recently realized, and consequently unchristened, principle. Flowers advertise. They acquaint bees with the fact that honey is kept within. But the philanthropy of the thing is only on the surface. This advertisement is displayed in as strict a business spirit as is any manufacturer's printed notification concerning soap or pills. Behind the whole proceeding is a concern that the bee should, though without intent or knowledge, put pollen to its appointed use. The advertisements of flowers are sometimes as fatal as those of the turf tipster. Little birds are attracted to the arum lily's seed pod by the seduction of its scarlet coat, and Professor Bottomley spoke by the book when he characterized the business as floral murder. The decayed body of the treacherously poisoned bird makes just the proper little heap of nutritive soil for the germination of the seed. Then, too, insects advertise, as Prof. E. B. Poulton, in the interesting lecture he delivered at the Royal Institution, made abundantly manifest. There are countless little creatures upon this earth who are concerned to pass themselves off as something they are not in order to escape the consequences of being what they are. The result is attained by advertisements, and lying advertisements to boot. Take the case of a certain humble bee, and of a certain still more humble fly. The latter is a veritable Beerbohm Tree in his capacity to assume the appearance of the former. Art for art's sake does not enter into the situation. The performance of the fly originates in a consideration of self-preservation. Professor Poulton showed that this interested imitation does not stop even at copying the brown and hairy coat. The toothsome insect actually apes the antics of the stinging insect, and notably in the matter of leg action. Be it known that in the cool of the evening, if you go up to tease the particular bee, he as like as not will disdain to fly away, but will waggle a pair of legs at you in a menacing manner eloquent of anger. Under similar provocation this little fly will do the same, the better to convey an erroneous idea that he is a bee and armed with a sting. One fault in the imitation is worthy to be noted. The bee does not use his front pair of legs for this alarming demonstration. The fly does, and this circumstance is easy to account for. While all the legs of a fly are equally useful for walking with, the front pair have got in the way of performing little extra duties. We have all seen flies washing their faces with the front pair, which have also a marked facility when outstretched for rapidly curling and uncurling round one another at the extremities—a performance which is probably directed to some other end than the promotion of circulation. Thus these forerunners were, by reason of their superior flexibility, singled out for this part of the strange business of fooling birds and other insect-eaters.

There are tasty beetles that pretend to be wasps, and plenty of nourishing flies that try and palm themselves off as unsavory ants. There is even a spider that assumes the appearance of an ant. At first sight it would seem that the possession of eight legs would be a bar to the disguise, but the ingenuity of nature, working through the principle of selection, is capable of what one is tempted to describe as daring solutions of difficult problems. When occasion requires, up go the front pair of legs as counterfeit antennæ. Some of our readers will be familiar with the quaint appearance of the caterpillar of the lobster moth—which to the ordinary eye is two-thirds caterpillar and one-third something else. The bulky appendage called by politeness a tail really seems, so far as unity of design is concerned, to have no relation to what goes before. And now note the explanation with which a distinguished Russian naturalist has staggered the entomological world. A fact patent to all observers is that the caterpillar of the lobster moth, when menaced by danger, will swing his tail over on to his back, and hold up his forelegs straight and quivering. Why he should behave thus has long been a mystery, for to the scientific mind it never seemed a sufficient explanation that the creature perchance aspired, by this appalling contortion, to fill his enemy's heart with paralyzing terror. The distinguished Russian one day bethought him of the strong resemblance the caterpillar's tail bears to a certain plant-bug that is repugnant to insect-eaters. When one comes to think of it, how simple the matter seems. The caterpillar's extended, quivering forelegs of course complete the likeness by figuring as the bug's antennæ. Is it likely a bird would swallow a caterpillar that has an unpalatable plant-bug glued to its back?

Instances might be multiplied. One South American fly which happens to be first-class eating goes about under a shield fashioned in the appearance of a highly indigestible ant, the creature having a parallel in those pantomime performers who walk enveloped in the canvas and plaster guise of monsters. As for butterflies, there are, as Professor Poulton pointed out, vast advertising communities among them.

TRADE NOTES AND RECIPES.

Gout Remedies.—Gout Wadding. Spread out thin ungreased cotton wool 2,000, sprinkle by means of an atomizer with clove oil 3, rosemary oil 3, cade oil 3, camphor 5, Venice turpentine 6, tincture of Spanish pepper 60, roll up and pack in parchment paper.

Gout Paper.—(a) Tincture of euphorbium 1, tincture of cantharides 1, tincture of Spanish pepper 2, iodine 2, turpentine 2, resin 40, absolute spirit of wine 60; filter and apply to fine tissue paper by means of a broad painting brush, dry and cut into suitable pieces.

Transparent Gout Paper.—(b) Cantharides 15, euphorbium 4, spirit 240; digest for a few days, filter and add pix navalis, melted at moderate heat, 180, Venice turpentine 6 and pix navalis until the liquid turns brown. Apply two or three times on tissue paper. Paint the back of the paper with oil of lavender.—Neueste Erfindungen und Erfahrungen.

Henchard's Antiseptic Mouth Wash.—

Crystallized carbolic acid	4.0
Eucalyptol	1.0
Salol	2.0
Menthol	0.25
Thymol	0.1
Alcohol	100.0

Dye with cochineal (1½ per cent).—Zahntechnische Reform.

Protection of Plants from Insects.—The summer season of course increases the demand for means to destroy insects that infest plants and the pharmacist should be prepared to supply it, as far as that can be done.

For protection against all non-masticating and many mandibulate insects, kerosene oil is much used. It is exhibited in the form of emulsion, which may be made as follows:

Kerosene	2 gallons
Common soap	8 ounces
Water	1 gallon

Dissolve the soap in the water by the aid of heat, bring to the boiling point and add the kerosene in portions, agitating well after each addition. This is conveniently done by means of the pump to be used for spraying the mixture.

For destroying scale insects dilute this emulsion with 9 times its volume of water; in the case of most others, except lice, dilute with 14 volumes, and for the latter with 20 to 25 volumes.

For the extermination of scale insects, resinous preparations are also employed, which kill by covering them with an impervious coating. Such a wash may be made as follows:

Rosin	3½ pounds
Caustic soda	1 pound
Fish oil	8 ounces
Water	20 gallons

Boil the rosin, soda and oil with a small portion of the water, adding the remainder as solution is effected.

For the San José scale a stronger preparation is required, the proportion of water being decreased by half, but such a solution is applied only when the tree is dormant.—Drug. Circ. and Chem. Gaz.

Silver Plating Without a Battery.—A thin film of silver may be deposited on brass, copper, etc., by the application of a paste composed of 2 parts of freshly-precipitated silver chloride, 3 parts of potassium bitartrate and, according to some writers, a small proportion of sodium chloride, the vehicle being water.

The article to be silvered must first be thoroughly freed from grease, an effective method of doing which is to immerse it for some time in a hot solution of caustic soda or potassa, and rinsing well in water. During the rinsing and afterward the article must not be touched with the fingers as it would thus again be slightly greased and, of course, firm adherence of another metal would be prevented.

The article having been so cleaned the paste is gently rubbed on it with a soft cork. Small articles may simply be immersed in the paste.

When the coating is considered sufficiently thick the object is washed in hot water and dried by shaking with sawdust.

The silver chloride required in the operation may be conveniently obtained by dissolving silver nitrate in distilled water and adding to this a solution of sodium chloride (common salt) as long as precipitation occurs; the precipitate so produced being washed to free it from any excess of the precipitant.

To obtain heavy coatings of silver on other metals, electro-deposition is employed.—Drug. Circ. and Chem. Gaz.

Depilatory.—Strontium sulphide is an efficient depilatory. A convenient form of applying it is as here directed:

Strontium sulphide	2 drachms
Zinc oxide	3 drachms
Powdered starch	3 drachms

Mix well and keep in the dry state until wanted for use, taking then a sufficient quantity, forming into a paste with warm water and applying to the surface to be deprived of hair. Allow to remain from one to five minutes, according to the nature of the hair and skin; it is not advisable to continue the application longer than the last-named period. Remove in all cases at once when any caustic action is felt. After the removal of the paste, scrape the skin gently but firmly with a blunt-edged blade (a paper knife, for instance) until the loosened hair is removed. Then immediately wash the denuded surface well with warm water, and apply cold cream or some similar emollient as a dressing.—Drug. Circ. and Chem. Gaz.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Our Trade Opportunities in Europe.—Until 15th of October next the municipality of Liege, Belgium, will receive bids for a new heating and ventilating plant for the Royal Theater at that city. Copies of specifications and plans for said plant can be had by sending 12 francs (about $2.50) to the Administration of Public Works of the city of Liege. Our systems of heating and ventilation are much superior to those prevailing in Europe. After the Europeans have once the ocular and practical proof of this by having the American system in operation in one or more of their cities it will then be easy to obtain profitable contracts frequently. "Only the beginning is arduous," says a German proverb. Here is an opportunity for our manufacturers in that line to make a beginning for foreign trade.—Simon W. Hanauer, Deputy Consul-General.

Conflict in the Swiss Cheese Market.—There is a conflict between the producers and the dealers in Swiss cheese in Switzerland, causing a suspension of the usual business of the season, through which our own dealers in this article might profit. The conflict is caused by the dealers insisting that the producers should comply with the old-fashioned custom of giving as a bonus an additional 6 per cent of the purchased weight.

The same difficulty occurred last year, and American buyers purchased direct from the producers, but the latter soon gave in and their entire output was immediately bought by the Swiss dealers.

This year, the Dealers' Association has agreed to impose a penalty of 1,000 francs ($193) on any member of the association who buys cheese without the bonus of 6 per cent, and in retaliation 500 cheese makers have entered into an agreement not to give more than the weight actually bought and paid for, in default of which they bind themselves to the payment of a fine of from 1,000 to 3,000 francs ($193 to $579).

The situation offers an excellent opportunity for foreign dealers to buy the finest and most valuable Swiss product at an exceptionally low price. Upon reliable authority, I am informed that French dealers have already availed themselves of the opening.—Henry H. Morgan, Consul at Lucerne.

Demand for Furniture, Automobiles and Machinery in South Africa.—Consular Agent W. D. Gordon, of Johannesburg, July 30, 1902, says:

I have been asked to get data as to household furniture, automobiles and autobicycles, and general farm machinery. If our manufacturers will send me prices, with weights, measurements, etc., I will place the information in the hands of the interested parties. In household furniture only the better grades should be quoted, as transportation charges are so high that the delivered cost of the better qualities is but little more than that of the inferior.

Fur Market of Leipzig.—Nearly the whole fur trade of the world concentrates itself in the two cities of London and Leipzig; but as about two-thirds of the London furs, which are sold at auction, go to Leipzig, the result is that the fur market of Leipzig is really the greater of the two. The Leipzig warehouses receive raw and half-prepared furs from Siberia, European Russia, America, Australia and China, making the business of the fur exchange worth from $15,000,000 to $17,000,000 yearly. The chief article of import is the raw Astrakhan from Bokhara, which comes via Nizhni Novgorod, this product reaching an importation figure of about 1,000,000 skins, each of which is worth from $2.06 to $3.35. With the cost of tanning and dressing added, the value of this trade amounts to from $3,000,000 to $3,500,000.

The second most important division of goods includes sable furs, of which about 50,000 skins, each worth from $50 to $100, are imported yearly. Of fox skins, nearly 30,000 pelts are tanned and dyed yearly. Lamb skins average about 1,000,000 per year.

Formerly Leipzig handled annually about 4,000,000 Russian squirrel skins, which were bought mostly in England; but as the fashion of long-fur garniture on ladies' dresses disappeared, the demand was reduced to 2,000,00 pelts. The tails for boas are mostly imitations of marten and sable tails. The sale of the pelt of the white fox in this market amounts yearly to about $500,000, which is about the whole available product of the world's markets.—Oliver J. D. Hughes, Consul-General at Coburg.

Fairs in Canada.—Commercial Agent F. S. S. Johnson, of Stanbridge, under date of August 25, 1902, says:

In order to more fully advertise United States goods in Canada, our manufacturers should arrange to send exhibits to the fairs which will be held next month in Quebec and Ontario. These exhibits should not be chosen at random, but should consist of the very best grade of goods. Farming implements and tools would undoubtedly be a great attraction and in all probability would open up a new market for these goods. Fairs will be held in the cities of Ottawa and Toronto, Ontario, and Sherbrooke, St. John's, and Bedford, Quebec.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

SELECTED FORMULÆ.

How to Produce Certain Colors in Painting.—In a paper by S. Paris Davis we printed some years ago in the Circular, we take the following formulæ for producing various colors by mixture of pigments. They will be of service to amateurs:

Bismarck Brown.—Take carmine, crimson lake and gold bronze, and mix together. If a light shade is desired, use vermilion in place of carmine.

Bottle Green.—Dutch pink and Prussian blue for ground; glaze with yellow lake.

Brick Color.—Two parts of yellow ocher, one of red and one of white.

Bronze Green.—Five parts of chrome green, one of black and one of umber.

Brown.—Three parts of red, two of black and one of yellow.

Canary Yellow.—Five parts of white and three parts of lemon yellow.

Carnation Red.—Three parts of lake and one of white.

Chestnut Color.—Two parts of red, one of black and two of chrome yellow.

Chocolate Color.—Add lake or carmine to burnt umber or take Indian red and black to form a brown; then add yellow to bring about the desired shade.

Citron.—Three parts of red, two of yellow and one of blue.

Claret.—Red and black, or carmine and blue.

Clay Drab.—Raw sienna, raw umber and white lead, equal parts; then shade with chrome green.

Copper Color.—One part of red, two of yellow and one of black.

Cream Color.—Five parts of white, two of yellow and one of red.

Deep Buff.—The same, with the addition of a little red.

Drab Color.—Nine parts of white and one of umber.

Dove Color.—Red, white, blue and yellow.

Fawn Color.—Eight parts of white, one of red, two of yellow and one of umber.

Flesh Color.—Eight parts of white, three of red and three of chrome yellow.

French Gray.—White shaded with ivory black.

French Red.—This color is simply Indian red, lightened with vermilion and glazed with carmine.

Gold Color.—White and yellow, shaded with red and blue.

Grass Green.—Three parts of yellow and one of Prussian blue.

Green.—Blue and yellow or black and yellow.

Jonquil Yellow.—Mix flake white and chrome yellow and add vermilion or carmine.

Lead Color.—Eight parts of white, one of blue and one of black.

Lemon Color.—Five parts of lemon yellow and two of white.

Light Buff.—Yellow ocher, tinted with white.

Light Gray.—Nine parts of white, one of blue and one of black.

Lilac.—Four parts of red, three of white and one of blue.

Maroon Color.—Three parts of carmine and two of yellow.

Medium Gray.—Eight parts of white to two of black.

Oak Color.—Five parts of white, two of yellow and one of red.

Olive Brown.—One part of lemon yellow with three parts of burnt umber. Change the proportions for different shades.

Olive Color.—Eight parts of yellow, one of blue and one of black.

Peach Blossom.—Eight parts of white, one of red, one of blue and one of yellow.

Pea Green.—Five parts of white and one of chrome green.

Pearl Color.—White, black and red in proportion to suit the taste.

Plum Color.—Two parts of white, one of blue and one of red.

Portland Stone.—Three parts of raw umber, three of yellow ocher and one of white.

Purple.—The same as lilac, but differently proportioned; say two parts of blue.

Rose Color.—Five parts of white and two of carmine.

Salmon Color.—Five parts of white, one of yellow, one of umber and one of red.

Snuff Color.—Four parts of yellow and two of vandyke brown.

Stone Color.—Five parts of white, two of yellow and one of burnt umber.

Straw Color.—Five parts of yellow, two of white and one of red.

Tan Color.—Five parts of burnt sienna, two of yellow and one of raw umber.

Violet.—Similar to lilac, but more red than purple.

Willow Green.—Five parts of white and two of verdigris.—Drug. Circ.

Furniture Paste.—

Paraffin wax	7 ounces
Petroleum jelly	2 ounces
Solution of potassa	5 drachms
Yellow wax	3 ounces
Alkanet root	1 ounce
Turpentine	12 ounces

Place the first four ingredients in a vessel and melt with gentle heat, then add the others, digest an hour and strain.—Drug. Circ.

Mahogany Stain for Wood.—Rub the surface of the wood with a solution of nitrous acid, and then apply, with a brush, the following:

Dragon's blood	1 ounce
Sodium carbonate	6 drachms
Alcohol	20 ounces

Filter just before use.—Drug. Circ.

Kid Glove Cleaner.—

Soft soap	1 ounce
Water	4 ounces
Oil of lemon	¼ drachm

Precipitated chalk, a sufficient quantity.

Dissolve the soap in the water, add the oil and make into a stiff paste with a sufficient quantity of chalk.—Drug. Cir.

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TABLE OF CONTENTS.

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